POWER

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The Fireman

By Berton Braley

OH, they build their dams and their power plants,
An' the scientists all announce
That I'm bein' swamped in the world's advance,
That I'm due fer the final bounce;
An' the gasoline engines "putt-putt-putt"
In a jubilant song uv glee,
A-celebratin' my de-mise, BUT
They needn't hang crepe on me!

No, I ain't gone yet
From the world, you bet!
I'm a hale an' a hearty soul;
An' I'm on the job
Where the boilers throb,
Shovelin', shovelin' coal!

THEY build 'em locos that run by "juice"
An' vessels that's driv by gas,
An' they say, "The fireman, he ain't no use,
He's one of the things that pass";
But somehow or other the coal gets burnt
All over the land an' sea,
There's plenty of things that the world has learnt,
But it hasn't got rid o' me!

Oh, I sweat an' stoop
As I swing my scoop,
An' toil fer my daily dole;
Where the grate's aglare,
You will find me there,
Shovelin', shovelin' coal!

THERE'S patent stokers to take my place
An' grates that'll clean themselves,
An' you'd think us guys was a dyin' race
To be laid on the dusty shelves;
But somehow or other we ain't quite through,
There's lots of us left, by Gee!
An' speakin' as one of the firemen's crew,
You need't hang crepe on me!

Oh, the grates they roar
As they yawn fer more,
An' I work in the stokin' hole;
An' fer many a year
You will find me here,
Shovelin', shovelin' coal!

Heating Chicago's Tuberculosis Sanitarium

By Thomas Wilson

SYNOPSIS—An interesting heating installation serving 56,000 sq.ft. of direct radiation. A good layout is enhanced by excellent workmanship and ingenious provisions to care for expansion, support of the piping, and the insurance of uniform distribution of steam to all buildings.

In 1911 the preparation of the plans for the City of Chicago's Municipal Tuberculosis Sanitarium was begun under the direction of the late Dr. Theodore B. Sachs. A quarter-section one-half mile square in the extreme northwest section of the city, about nine miles from the downtown district, had been selected as the site. It was first intended to limit the number of patients to 300, but from time to time the plans were modified to gradually meet the needs of the tuberculosis situation in the city.

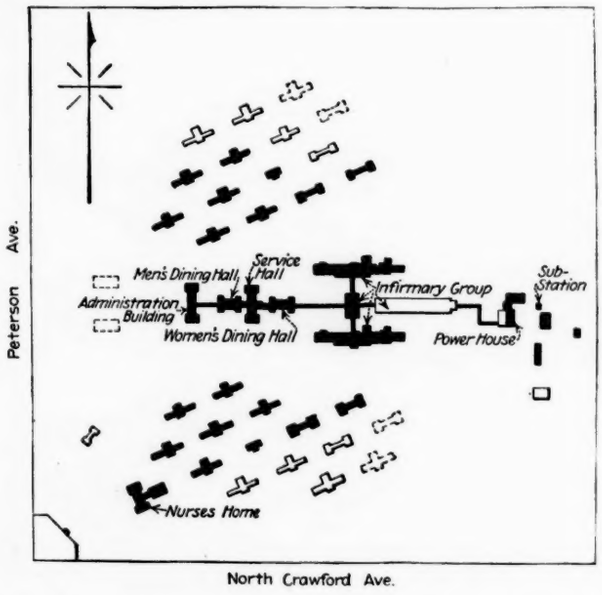


FIG. 1. PLAN OF SANITARIUM BUILDINGS AND COTTAGES

In its present state the sanitarium will care for 1500 to 2000 patients annually. Patients were first admitted in March, 1915.

As shown in Fig. 1, the present layout contains an administration building, service building, dining halls, infirmary group and power house, all arranged on the median line of the grounds, running from east to west. This divides the grounds into two sections, the south section being reserved for the cottages for women patients and the north section for men. The solid templets indicate completed buildings; those outlined by full lines, proposed new buildings; and the dotted outlines, future cottages. The sanitarium buildings now occupy approximately 45 acres, leaving 115 acres for future buildings and a produce farm to supply all vegetables needed.

Primarily the power plant serving the institution was erected for heating, although considerable steam under pressure is supplied for the laundry, kitchens, sterilizers and other similar uses. Current is purchased from the Sanitary District. The sanitarium being a city institution, was entitled to a rate approximating 1¼c. per kw.-hr. The contract included a provision to operate, at the discretion of the sanitarium board, a 312-kv.-a. turbogenerator installed at the plant, during the three coldest months of the heating season. All the exhaust steam and more can be used for heating, and the cost of current during this period would be little more than the interest on the investment and the depreciation of the unit. The turbine is of the multiple-stage bucket and nozzle impluse type operated noncondensing with a bypass provided so that it can develop 50 per cent. overload with steam at 110 lb. pressure. The water rate runs about 30 lb. per b.hp.-hr.

In case of accident to the service lines, the turbine may be used for breakdown service. This factor decided its installation, as failure of electric supply would be disastrous to an institution of the kind. A throw-over switch is provided so that a change can be readily made from one service to the other.

Three-phase 60-cycle current from the Sanitary District comes into a transformer house near the power plant at 12,000 volts. It is here stepped down to 440 volts, and by other transformers serving groups of buildings it is further reduced to 220 volts for power and 110 volts for lighting.

Refrigeration is provided by a 25-ton carbonic anhydride plant, which by brine circulation cools eight large refrigerators in the Service Building and a number of small ones in the cottages. In addition the plant has capacity to make 500 lb. of ice per day in a raw-water ice system and cool 100 gal. per hr. of drinking water from 75 to 45 deg. F. The compressor, with a cylinder 4⅜x20 in., is belt-driven by a 40-hp. induction motor. The condenser is of the double-pipe type arranged in two sections ten pipes high. In the main tank the brine temperature ranges from 10 to 12 deg. The condenser pressure is maintained at 65 atmospheres and the suction pressure at 20 atmospheres.

As previously stated, heating is the major service. A steam vacuum system serves the 56,000 sq.ft. of direct radiation now installed. The arrangement is excellent and the construction high-grade throughout. Three water-tube boilers, each containing 2220 sq.ft. of heating surface, supply the steam. Two of the boilers are equipped with chain-grate stokers and the third with a hand-fired rocking grate. Natural draft is supplied by a brick stack 5 ft. 4 in. diameter, rising 172 ft. above the grates. The operating pressure is 110 lb. gage. From an underground bunker coal is conveyed to the boilers in an industrial car. An elevator raises the ashes above grade and spouts them into wagons. The layout of the plant is shown in Fig. 2.

One of the distinctive features of the institution is the tunnel connecting the central buildings on the median line of the property. It traverses a distance of 1550 ft., is 7 ft. wide and 9 ft. high. The tunnel accommodates all service pipes, including steam, water, return, refrigeration, electric and telephone conduit; affords an underground passageway between buildings which may be used

for the transportation of food and supplies, and its roof serves as a concrete walk between the central buildings. The heating mains are carried in this tunnel. One of 10-in. diameter supplies the Infirmary Group and a certain proportion of the cottages, while the other, a 12-in. line, supplies the Service and Administration Buildings and the balance of the cottages. Underground loops starting at the Infirmary Group and ending up at the Service Building serve the cottages on either side. The loops may be supplied with steam from either main, and the latter are cross-connected at the Infirmary Building so that steam for all buildings may come through either main. Although steam for the kitchens and the laboratories is conducted at boiler pressure through the tunnel and is reduced at the point of service, that for heating is reduced in the power plant to 3 or 4 oz. pressure. A vacuum of 7 in. is carried at the pumps in the power house. A uniform condition of vacuum is maintained in each building by means of Hylo vacuum controllers and traps, which are installed in the trench return lines. At the Nurses' Home, a distance of 2500 ft. from the power plant, the vacuum gage averages 3 in. and indicates a drop of only 4 in. This, of course, is unusual and speaks well for the layout of the system.

Fig. 3 shows piping details of the heating system and methods of support in the tunnel. The two heating mains are supported by I-beams set into the tunnel walls. The upper pipe is upheld by rollers resting on cast-iron base plates bolted to the tops of the I-beams, while the lower pipe is swung from the bottoms of the I-beam supports by trapeze hangers. This is shown in the detail section *A B* of Fig. 3.

The high-pressure steam mains and return lines, hot water and brine pipes are suspended from the I-beams forming part of the roof construction of the tunnel. The lower flanges of these beams project 2 in. under the concrete roof slabs to facilitate attachment of the pipe hangers. An angle-iron rack supports the heating returns near the bottom of the side wall of the tunnel.

In the long runs of piping connecting the buildings, it was realized that careful provisions must be made for expansion. Preliminary calculations showed that the expansion of 1.3 in. per 100 ft. could be expected for the heating mains. Observations after the work was completed proved that the estimate was correct to within 0.01 in. In other words, the actual expansion was 1.29 in. per 100 ft. of piping. The U-bend and the four-elbow three-nipple method with offset were employed to care for the expansion, the latter method being used at points of change in direction of the tunnel run. Recesses at the side of the tunnel 20 ft. long and 8 ft. wide were provided for the U-loops. The method of supporting the piping

PRINCIPAL EQUIPMENT OF CHICAGO'S MUNICIPAL TUBERCULOSIS SANITARIUM POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Boilers	Water-tube	222-hp.	Generate steam	Natural draft, stoker and h.-f. grate	Kroeschell Bros. Co.
2	Stokers	Chain-grate	47.2-sq.ft.	Serve boilers	Driven by Wachs engines	Green Engineering Co.
1	Grate	Rocking	6x8-ft.	Serve boiler		U. S. Rocking Grate Bar Co.
2	Stoker engines	Vertical	4x5-in.	Drive stokers		E. H. Wachs Co.
1	Heater	Open	700-hp.	Heat feed water	Exhaust steam	Warren Webster & Co.
2	Pump	Duplex	7½x5x6-in.	Boiler-feed water		Henry R. Worthington
1	Turbine	Impulse	420-b.hp.	Generating Unit	110 lb. steam, 3,600 r.p.m.	Kerr Turbine Co.
1	Generator	A.C.	312-kv.-a.	Generating Unit	480 volts, three-phase, 60-cycle	Allis-Chalmers Co.
1	Compressor	Carbon dioxide	4⅜x20-in.	Serve refrigerating plant	20-65 atmospheres; driven by 40-hp. G.E. induction motor	Kroeschell Bros. Ice Machine Co.
1	Condenser	Double-pipe	Two section 10-pipes high.	Refrigerating plant	65 atmospheres	Kroeschell Bros. Ice Machine Co.
2	Pumps	Duplex	10x7x10-in.	Brine		Henry R. Worthington
2	Pumps	Simplex	10x12x12-in.	Vacuum heating system	7-in. vacuum	American Steam Pump Co.
2	Pumps	Duplex	14x10½x10-in.	House service	Raise water to 60,000-gal. press. tank	Henry R. Worthington

Insulation for brine and steam pipes and underground conduit for heating, H. W. Johns-Manville Co.; Homestead and Cadman blowoff valves; American pop safety valves; Crane water and steam valves; Anderson steam traps; Foster nonreturn valves; Warren Webster vacuum heating system; Maloney transformers.

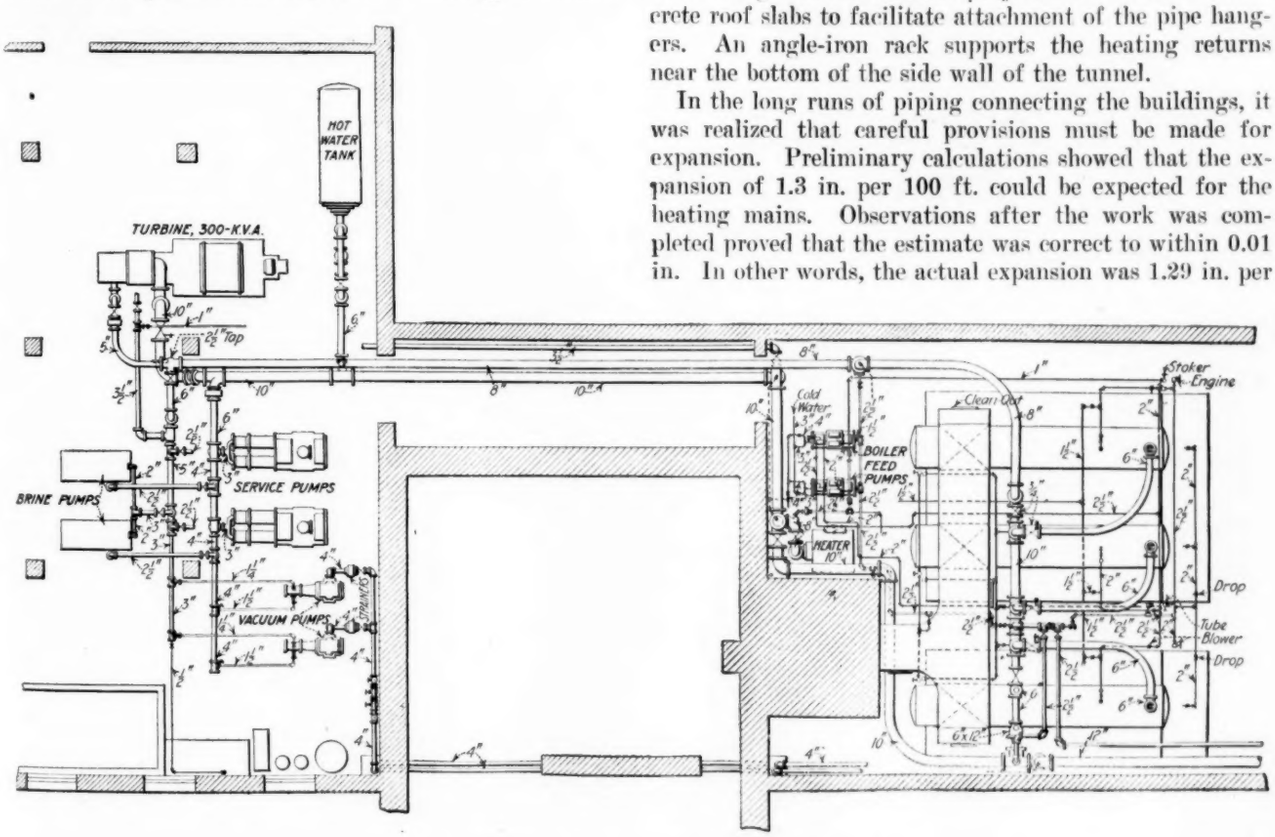


FIG. 2. PIPING LAYOUT OF POWER PLANT

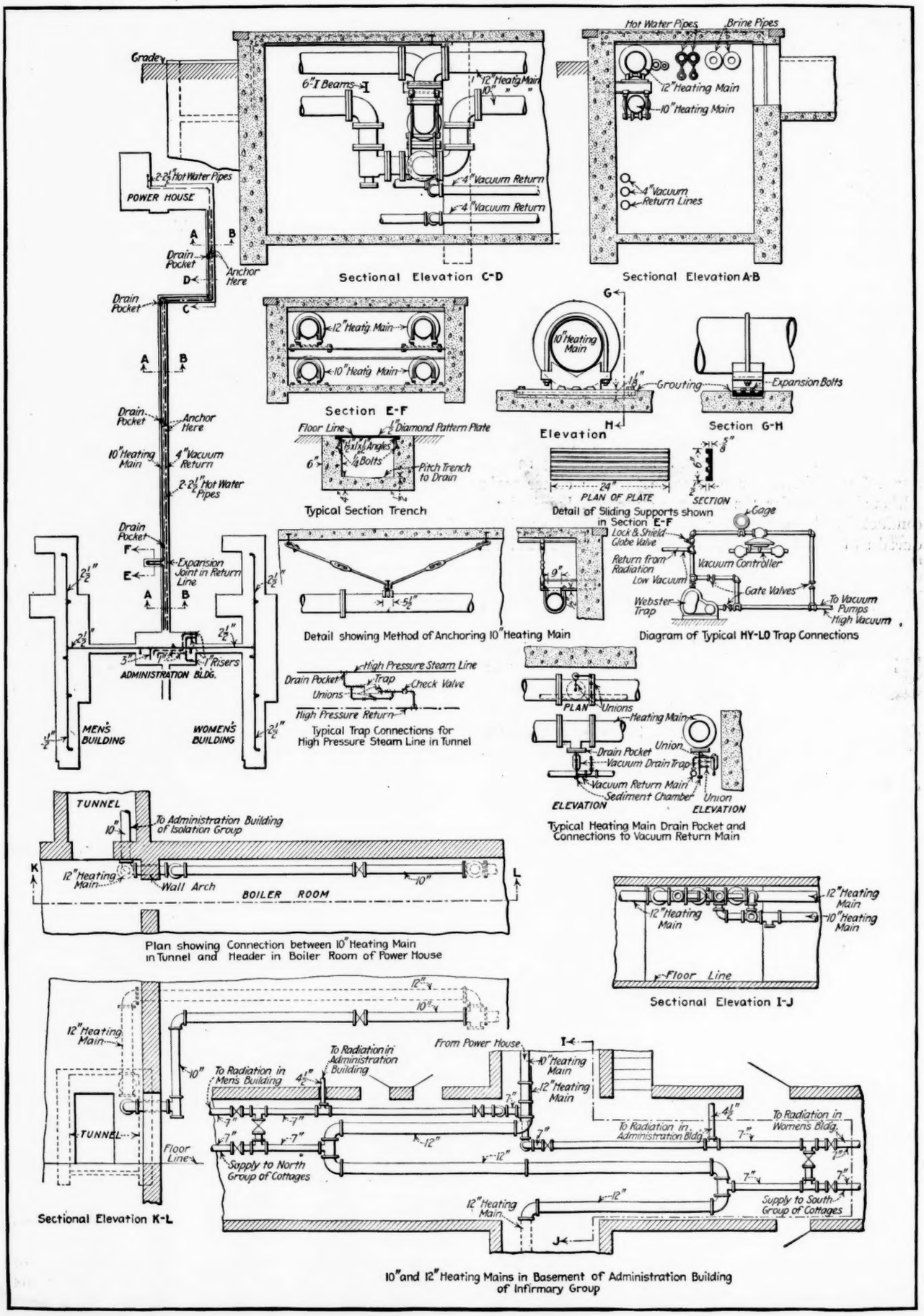


FIG. 3. DETAILS OF TUNNEL AND HEATING MAINS TO INFIRMARY GROUP

is shown in the sectional detail *E—F*, Fig. 3. In the various smaller lines expansion was cared for in the same way. No slip joints have been used on any part of the work. Between the expansion elements anchors were installed, one method of attachment being shown in Fig. 3. Other details shown in this cut are typical trap and drain-pocket connections.

To the various cottages and outlying buildings the transmission lines are carried in tile conduit buried 3 ft. to the top of the tile. Split vitrified tile with roughened edges which are cemented together after the pipe has been laid, are used. The lower section rests on crushed limestone. A 4-in. tile underdrain connected to the sewer at various points is provided below the conduit. The conduit is of sufficient size to permit the installation of the heating supply and return mains and two hot-water circulating pipes. At intervals supporting tees are provided in the conduit. The tee rests on and incloses

FIG. 4. INSTALLATION OF UNDERGROUND CONDUIT

a concrete base, which also supports a roll frame for the piping. The weight of the pipes and their contents is thus removed from the tile, and the movements of the pipe do not affect the conduit.

For the most part expansion is taken care of in the various building basements by offsets and loops. In certain of the lines U-bends were employed, large concrete waterproof chambers having been installed here to permit inspection and repair. The pipes are anchored in manholes at various intersection points.

Sponge filler is used as insulation. The method of packing it around the piping in the conduit is shown in Fig. 4. This type of conduit construction has repeatedly shown a transmission efficiency of over 90 per cent. It is certain that the insulation used in the present work is good, as the transmission lines cannot be traced by indications in light snowfall.

The addition of new buildings and the constant increase in the demand for steam have necessitated an addition to the boiler plant. This is now under way and will contain two 400-hp. water-tube boilers equipped with chain-grate stokers, two boiler-feed pumps and a feed-water heater large enough for the entire plant. A duplicate refrigerating plant will also be installed. Coal-handling apparatus is a possibility for the future, but will not be included in the present addition.

For the completed work W. A. Otis and E. H. Clark were architects and Neiler, Rich & Co., of Chicago, consulting engineers.

Accuracy of Temperature Determinations

By L. A. Wilson

The mercury thermometer, which is undoubtedly the simplest and most widely used of the various devices available for temperature measurement, may, under certain conditions, lead to serious errors unless properly used and subjected to necessary corrections not ordinarily provided for in the usual methods of calibration. What is commonly known as "stem correction" often amounts to several degrees and should always be applied when the measured temperature differs greatly from that of the surrounding atmosphere. For the Fahrenheit scale,

$$\textit{Stem correction} = 0.000088n(T - t)$$

where T is the measured temperature, t the mean temperature of the exposed stem, and n the number of degrees of exposed mercury column. To illustrate the magnitude of this correction, assume that the reading of the thermometer is 400 deg. F. and that there is 300 deg. of exposed column. Also suppose that the mean temperature of the emergent stem is 100 deg. F. By direct substitution in the formula, it is found that the true temperature is 8 deg. higher than indicated by the thermometer. In extreme cases it might be necessary to approximate the true temperature in this manner and then use that value to find the stem correction.

Bulb Pressure Causes Inaccuracies

There is another source of error that is frequently overlooked and that assumes serious proportions if the bulb of the thermometer is exposed to high-pressure gas or steam. Pressure on the bulb increases the readings about one degree for each hundred pounds; this correction, then, should be subtracted from the observed readings.

The importance of avoiding the use of thermometer cups, and of using a thermometer of small mass, was heralded by Armand Duchesne at the University of Liége. In his experiments a mercury thermometer in a thin metal well was compared with a specially constructed and carefully calibrated thermocouple exposed directly to a current of superheated steam, and in the extreme case, where the temperature was 550 deg. F. (about 310 deg. of superheat), the difference amounted to 150 deg. This discrepancy seems to depend directly on the amount of superheat and to some extent on the rarefaction of the fluid. In similar experiments where the bulb of the thermometer was in intimate contact with the steam, the error amounted to only a few degrees. A properly calibrated thermocouple exposed directly to the fluid is probably the most accurate means for determining the temperature of superheated vapors or hot gases, unless the characteristics of the gases or vapors are such that their action would cause chemical changes in one or both of the elements. If a mercury thermometer is used, its degree of accuracy will depend to a large extent on the protection against heat loss by conduction through the stem.

Temporary Electric Heaters

By N. L. Rea

SYNOPSIS—How to construct temporary electric heaters, for drying out transformers, generators or other electrical equipment, from such materials as may be found around most any power house.

Large quantities of hot air are occasionally needed temporarily for drying transformers or other power-station equipment. Extra power is usually available from the exciter or station-service busses. This combination of circumstances has brought about the construction of temporary electric heaters.

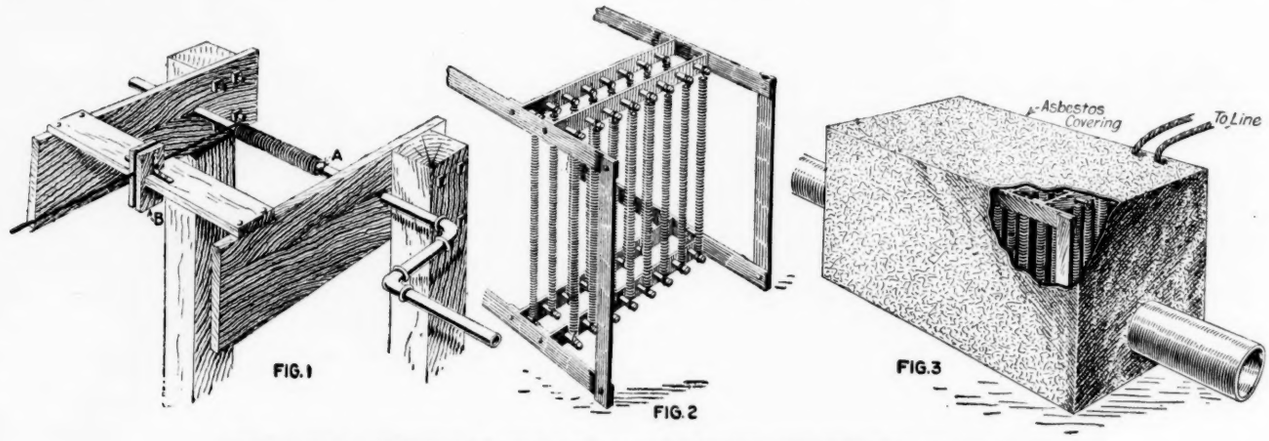
At first it was found almost impossible to get any data on this subject, and our early heaters were built largely by the "cut-and-try" method. These heaters were intended for temporary use and were built out of material usually available around the average power house. While they may have been crude in appearance, they had the saving grace of being cheap and doing the work. No. 13 B. W. G. telephone wire is generally available and has therefore been used in the majority of cases. The customary procedure, where the power circuit is 125 volts, is to wind a test coil of 125 turns on a mandrel made of ½-in. iron pipe or conduit. This coil is usually a little long, and should be tried with current and shortened until the proper heating is secured. These coils will take approximately 10 amp. and should just show red.

A lathe is not always available, and experience has evolved the arrangement shown in Fig. 1. The crank is made of odd lengths of ½-in. conduit and pipe fittings and mounted in two ⅞-in. holes bored in parallel planks, tacked to a post or swung in a packing case. A small hole *A* is drilled through the pipe to hold the end of the wire for starting the coil. The necessary tension can be put on the wire by two pieces of wood *B* bolted loosely together, a carpenter's wooden clamp and a piece of leather, or a dozen other schemes that will suggest themselves.

If the heater is used on alternating current, a decidedly shorter coil is required on account of the reactance. However, a few minutes' experimenting will settle the details of the individual coils, and experimenting is in this case decidedly easier and quicker than elaborate calculations.

The proper size of the individual coils being determined, work on the heater can proceed, the total number of coils depending on the amount of power available and the heat required. The heater must of course be fairly fireproof and, in addition, air-tight if it is intended for transformer drying with a blower.

Fig. 2 shows the construction of the heater frame, which is made of ¼x1-in. bar iron or whatever stock is available, bent cold and fastened together with stove bolts. Common porcelain knobs are used, as shown, for supporting the coils. It is advisable to drill the cross-bars a little off center so as to stagger the coils by reversing every other pair of bars, as shown. This will give a better heat distribution. The heater should be long and of a relatively small cross-section, as this will give better results as well as a more rigid framework.



FIGS. 1 TO 3. SHOW DETAILS OF CONSTRUCTION AND HEATER COMPLETE

The completed heater should be inclosed in sheet iron and lagged, as in Fig. 3. If iron is not available, wood liberally lined with asbestos may be used. For lagging, either magnesia pipe covering or some of the asbestos cements, which usually can be obtained from any dealer in steam fittings or hot-water heaters, may be used. This is mixed with water and plastered on the outside of the heater, and as it can be broken up, mixed and used again, the salvage value is fairly high. In other cases also, pipe-covering cement may be used, which later can be used on the permanent steam piping of the building. This covering also helps materially in making the heater casing air-tight. In any case the box is fitted on the ends with pipe connections for the blower and the hot-air delivery pipe. Six-inch stove pipe is a standard article and always obtainable. It also has a fair salvage value. Two or more pipes may be used in multiple on very large heaters.

Extreme air temperatures may sometimes prove disastrous, and for this reason an electric heater, or in fact, any heater connected to a blower, must be used with caution. Interruption of the normal air flow will cause an extremely rapid rise of the discharge-air tem-

perature. In one case it was found experimentally that with a heater adjusted to deliver air at 80 deg. C.—100 deg. C. being the limit of safety—running off the blower belt caused a rise of 100 deg. C. in the discharge air in ten seconds. The inherent rise of resistance of the iron wire with a temperature increase will protect the rheostat itself, but the high air temperature may damage the apparatus that is being dried out.

Several ingenious schemes have been devised for deflecting the air or opening the rheostat switch in case of blower failure. Fig. 4 shows one of the simplest contrivances for opening the heater switch. It is crude, but it is also cheap and reliable. A piece of board 4 or 5 ft. long is hinged to a short plank; a heavy weight is fastened on one side of the board at the upper end. The board is then placed to partly cover the fan inlet and set so the fan suction will hold the board and its attached weight upright. The board should be arranged so that it will drop when the blower is stopped. The plank is held in position by weights or by nailing to the floor after it is properly located. The top of the board is connected with a cord to the heater switch.

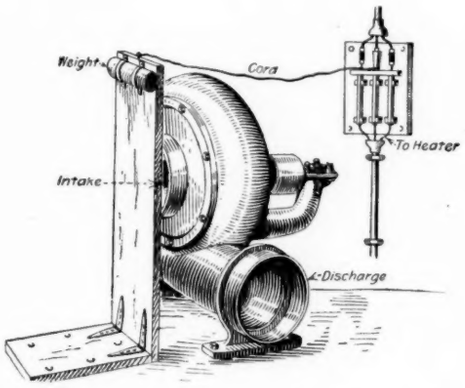


FIG. 4. SCHEME FOR DISCONNECTING THE HEATER IN CASE THE BLOWER STOPS

Enough slack should be left in this cord to permit the board and its weight to gain sufficient momentum to positively open the switch.

The temperature of the outgoing air is best regulated by varying the motor speed when direct-current apparatus is used. Speed variation is, of course, impractical with induction motors; in which case variation of the blower-intake opening will give good results.

The equipment, as outlined, is of course intended for emergency work or on short jobs where time presses. It is advisable to secure one of the standard equipments when time permits.

Fig. 5 shows an equipment built for transformer drying. The heater, or rheostat proper, consists of a cylindrical galvanized-iron casing, lined with asbestos and terminating at each end in a cast-iron cone, having feet for mounting on the base frame of light I-beams. The heater contains eight cast-iron grids connected all in series for 220 volts, and two groups of four in series connected in parallel for 110 volts. This heater is about 30 in. long and 10 in. in diameter. This outfit will carry 25 kw. continuously without becoming red-hot when 800 cu.ft. of air is passing through it per minute.

The blower is built as an exhauster, so that all the air must pass through a cheese-cloth strainer tied over the large galvanized-iron cone attached to the inlet. This is of ample capacity and is so arranged that the cloth may be easily attached and removed. The blower is run at speeds from 3100 to 3500, depending on the desired temperature of the air. This speed range gives from 800 to 850 cu.ft. per min. and temperature of from 85 to 100 deg. C., the temperature

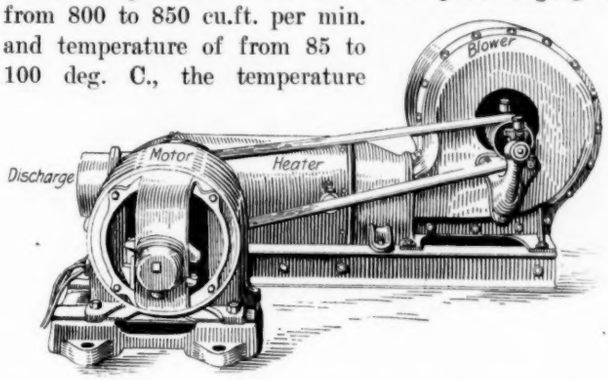


FIG. 5. STANDARD ELECTRICAL HEATING EQUIPMENT FOR DRYING TRANSFORMERS

varying inversely as the speed and the amount of air delivered. The fan requires about two horsepower, and any type of motor may be used.

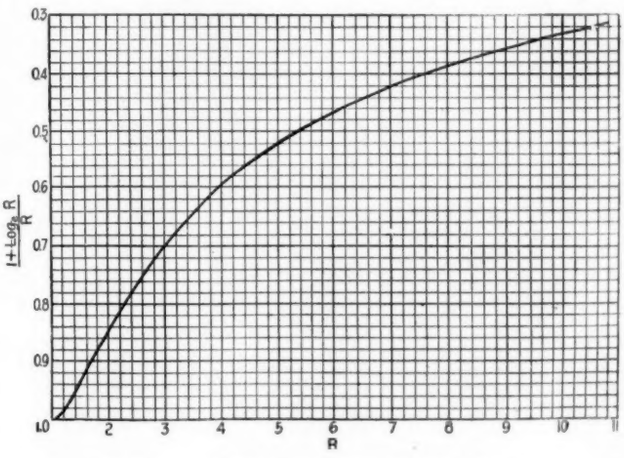
Calculating Mean Effective Pressures

By L. V. Curran

For convenience in cylinder computations involving the use of the formula,

$$P_M = \left[P_1 \times \frac{1 + \log_e R}{R} \right] - P_2$$

in which P_M = mean effective pressure, P_1 = absolute initial pressure, P_2 = absolute final pressure and R = ratio of final to initial volumes, a curve showing the relation of $\frac{1 + \log_e R}{R}$ and R will be found useful. In cases where a change in the initial or back pressure is contemplated, the previous water rate being known, the new



RATIO OF FINAL TO INITIAL VOLUMES

ratio of expansion and steam requirements can be approximated by solving the transposed equation $\frac{1 + \log_e R}{R} = \frac{P_M + P_2}{P_1}$ for the value $\frac{1 + \log_e R}{R}$ and finding the corresponding value of R from the curve. By this means a cut-and-try use of the hyperbolic logarithm tables is avoided.

The Loss of Coal Through Grates

By Carleton W. Hubbard*

SYNOPSIS—The loss of coal through the grates of an industrial plant is not a spectacular affair. It is rare that anyone connected with the plant concerns himself with it unless it has become so excessive that the ash pile catches fire. Like all other easily preventable losses that run their daily course, this constant slipping through the grate of combustible matter is taking dollars out of the profits. This article discusses the subject and gives two methods of determining the fuel loss through the grates.

There are two methods of determining the extent of fuel loss in the ashpit refuse in any given plant. The refuse that is shoveled out of the ashpit as ashes always contains more or less combustible matter. In this article the material that is removed from the ashpit will be called *refuse* and that part that is neither combustible nor moisture will be called *ashes*.

Some plants make a practice of weighing the coal as fired and also the amount of refuse removed from the ashpit. This is usually done not with the idea of determining the amount of combustible in the refuse, but of getting a figure for what is commonly, but incorrectly, called the ash in the coal. Under the best of conditions a certain amount of combustible will pass through the grate, and the amount of refuse removed from the ashpit gives only a slight clue as to the actual amount of ash in the coal and furnishes no direct measurement of the amount of combustible lost through the grates. If the plant systematically has its coal sampled and tested, the information thus furnished, together with a knowledge of the amount of coal fired and refuse removed, furnishes all the data necessary to solve the problem. For instance, if 1,200,000 lb. of coal is consumed per month and there is removed from the ashpits 180,000 lb. of refuse in the same time, it might be considered that the coal contained 15 per cent. of ash. If the coal used was sampled and tested and the tests showed that the coal as fired contained 12 per cent. of ash, it would be evident that the loss of combustible through the grates was 3 per cent.; if the tests showed that the coal contained 8 per cent. of ash, the loss through the grates would be 7 per cent. of the coal as fired.

Combustible from Ashpit Refuse

Another somewhat theoretical method of determining the amount of combustible lost through the grates, but which in practice has checked up closely with the results obtained by the first method, consists of sampling the refuse from the ashpit and determining the amount of combustible in it. It should be understood that the expression, "22 per cent. of combustible in the refuse," means that 22 per cent. of the sample of refuse is combustible matter and does not mean that 22 per cent. of the combustible matter shoveled into the furnace found its way into the ashpit.

This method, like that of weighing, requires a knowledge of the proximate analysis of the coal, but it has a decided advantage over the first method in that it is not necessary to weigh the ashpit refuse. It may be objected that this method makes too much depend on the sampling of the refuse, and this is a valid objection but not an unconquerable one. In a plant where the two methods were being used at the same time, and without any knowledge on the part of the operating force that one was being tested against the other, the results over a period of two years checked closely. There is no special reason why they cannot be duplicated elsewhere.

The second method is a more rational one of determining the loss of fuel than the first, which depends entirely upon weights and tacitly assumes that all parts of a pound of the combustible matter in coal is of equal heat value. This is contrary to the facts, for it is easily demonstrable that, pound for pound, the volatile matter in the coal produces more heat than any other part. In developing this method, it became necessary to determine the character of the combustible in the refuse.

No Volatile Matter in Refuse

A lengthy series of experiments were run on samples of refuse from coal of the four following classifications: Anthracite, semianthracite, semibituminous and bituminous. It was found that, no matter what kind of coal was used, the combustible in the refuse contained practically no volatile matter and was in reality nothing but coke. Owing to the large amount of ash accompanying this combustible, it was impossible to burn it in a calorimeter in order to find its heat value, and there appeared to be no serious error involved in assuming that the heat value of this combustible was the same as that of carbon; namely, 14,500 B.t.u. per lb.

It now becomes necessary to derive an expression whereby the percentage of combustible in the refuse can be translated into terms of coal as fired. In deriving this the following notation will be used: Let

R = The total refuse (this is unknown unless determined by weighing);
Y = The percentage of combustible in the refuse;
A = The percentage of ash in the coal as fired;
h = The calorific value of the combustible in the refuse = 14,500 B.t.u. per lb.;
H = The quantity of heat represented by the combustible in the refuse;
X = The percentage loss of coal as fired due to the combustible in the refuse.

If Y equals the percentage of combustible in the refuse, the percentage of ash in the refuse will be $100 - Y$ and the total amount of ash in the refuse will be $R(100 - Y) \div 100$. If it is assumed that dust and cinders are not carried up the stack, all the ash in a given quantity of coal will be found in the ashpit. The ash in the refuse is therefore equal to the ash in the coal, or expressed algebraically, $\frac{R(100 - Y)}{100} = \frac{A}{100} \times$ lb. of coal burned. Transposing this equation, $R = \frac{A \times \text{lb. coal burned}}{(100 - Y)}$. From the foregoing it is evident that the total amount of combustible in the refuse

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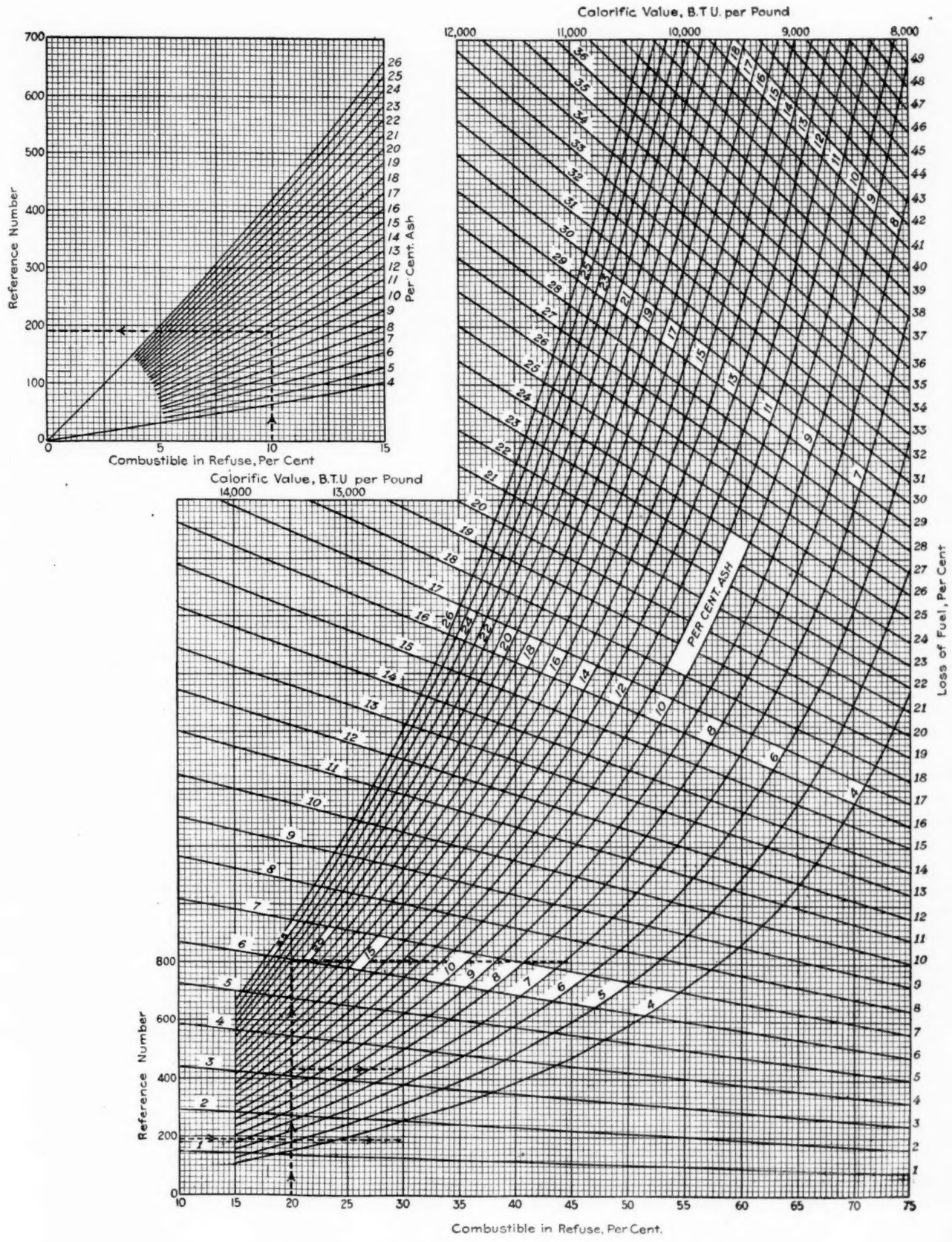


CHART TO DETERMINE LOSS OF COAL THROUGH GRATES

To use the chart with, say, 20 per cent. combustible in the refuse and 12 per cent. ash in the coal that has a heat value of 12,515 B.t.u., start at the bottom at the figure 20, indicating the per cent. of combustible in refuse, and run vertically up to the curved line marked 12 representing the percentage of ash in the coal. Then run horizontally to the right to the vertical line representing 12,515 B.t.u. per lb. The loss is therefore 3.5 per cent. The chart in the upper left-hand corner is used in the same manner. With 10 per cent. combustible in the refuse; coal with a heat value of 12,515 B.t.u. and containing 12 per cent. ash, start at the line 10 and run vertically to the curve 12 and then horizontally to the left. Read the reference number 190 and then using the same reference number on the larger chart run horizontally to the vertical line 12,515 B.t.u. (see bottom dotted line). This point is midway between lines 1 and 2, and represents 1.5 per cent. loss of coal through the grates

is $R \times Y \div 100$; and by substituting in this expression the value of R the total amount of combustible in the refuse = $\frac{A \times \text{lb. coal burned}}{100 - Y} \times \frac{Y}{100} = \frac{A \times Y \times \text{lb. coal burned}}{(100 - Y)100}$.

These terms are determinable from data furnished by the proximate analysis of the coal and a laboratory determination of the percentage of the combustible in the refuse. As the calorific value of this combustible matter is probably the same as that of carbon, the total quantity of heat represented by all the combustible in the refuse may be expressed as,

$$H = \frac{h(A \times Y) \times lb.\ coal\ burned}{100(100 - Y)} =$$

$$\frac{14{,}500(A \times Y) \times lb.\ coal\ burned}{100(100 - Y)} =$$

$$\frac{145(A \times Y) \times lb.\ coal\ burned}{100 - Y}$$

Now H is expressed in B.t.u., and in order to express the amount of coal lost owing to the presence of combustible in the ashpit, it is necessary simply to express the amount of heat H represented by the combustible in the refuse as a percentage of the amount of heat in the coal as fired. This can be done as follows:

$$X = \frac{14{,}500 \times A \times Y \times lb.\ coal\ burned}{(100 - Y) \times B.t.u.\ in\ 1\ lb.\ coal\ fired \times lb.\ coal\ burned}$$

or

$$X = \frac{14{,}500 \times A \times Y}{(100 - Y) \times B.t.u.\ in\ 1\ lb.\ coal\ as\ fired}$$

This last equation makes it evident that the loss of coal increases with an increase of either the percentage of ash in the coal or the percentage of combustible in the refuse, and in both cases the increase is in proportion to some power of the percentage of ash, or the percentage of combustible in the refuse, which power is always greater than unity. This is evident from the fact that an increase in the percentage of ash in the coal not only causes an increase in the numerator, but also causes a decrease in the denominator, because an increase in the ash displaces a like amount of combustible matter from the coal and so reduces its calorific value per pound. From the form in which Y appears in the equation, it is evident that as Y increases, the numerator of the formula increases and the denominator decreases. From these two facts the following deductions may be drawn: (1) With a coal running high in ash, a given percentage of combustible in the refuse represents a larger loss than the same percentage of combustible in the refuse would cause with a coal having a lower ash percentage. (2) With a constant percentage of ash in the coal, the loss increases rapidly as the percentage of combustible in the refuse increases. To make this clear an example is given.

Example: Percentage of ash in coal as fired = 17.21; B.t.u. per lb. in coal as fired = 11,780. What will be the loss of coal when the percentage of combustible in the refuse is 10?

When $Y = 10$,

$$X = \frac{14{,}500 \times 17.21 \times 10}{(100 - 10) \times 11{,}780} = 2.35\ \textit{per cent.}$$

With a percentage of combustible of 20 and 30, the loss of coal will be 5.29 and 9.07 per cent. respectively.

To show how much less important these same percentages of combustible in the refuse would be with coal containing a smaller percentage of ash, the following example is given:

Example: Percentage of ash in coal as fired = 8.64; B.t.u. per lb. in coal as fired = 13,934. What will be the loss of coal when the percentage of combustible in the refuse is 10?

When $Y = 10$,

$$X = \frac{14{,}500 \times 8.64 \times 10}{(100 - 10) \times 13{,}934} = 1\ \textit{per cent.}$$

With a percentage of combustible of 20 and 30, the loss of coal will be 2.24 and 3.85 per cent respectively.

It is not strictly fair to compare the two examples, as the figures used in the first one are about the average ash and heat found in No. 1 buckwheat and those in the second are about the average for semibituminous coal. These examples show that the percentage of combustible in the refuse is a meaningless figure unless it is taken in connection with the percentage of ash in the coal. To show this more conclusively, the following example is worked out, showing the percentage loss of coal for a given percentage of combustible in the refuse, with two shipments of the same coal having different percentages of ash.

Example: Percentage of ash in coal as fired, delivery No. 1, 12; delivery No. 2, 22; B.t.u. per lb. in coal as fired, delivery No. 1, 12,515; delivery No. 2, 11,030. What will be the loss of coal if each of these coals are burned in such a manner that the combustible in the refuse is 20 per cent.?

Delivery No. 1

$$X = \frac{14{,}500 \times 12 \times 20}{(100 - 20) \times 12{,}515} = 3.48\ \textit{per cent.}$$

Delivery No. 2

$$X = \frac{14{,}500 \times 22 \times 20}{(100 - 20) \times 11{,}030} = 7.23\ \textit{per cent.}$$

These losses are not exactly in proportion to the amounts of ash present in the two coals, and this is only to be expected, for an increase in the amount of ash causes a decrease in the amount of combustible in the coal and consequently a decrease in its calorific value per pound. To state it in another way, the increase in the percentage of ash increases the numerator of the formula and at the same time causes the calorific value of the fuel per pound, which appears in the denominator, to decrease.

The author has had an opportunity to check the working of this formula against the weighing method at a certain plant during 1914 and 1915. All the coal was weighed as fired, and the weight of the ashpit refuse was also determined. All the coal and ashpit refuse was sampled and each week the coal tested for ash, moisture and B.t.u. and the refuse for combustible matter. On the coal-test report is given the loss of coal due to the combustible in the refuse as determined by the formula. The plant determines the loss through the grates by expressing the total weight of the ashpit refuse as a percentage of the total weight of coal fired and subtracting from this percentage the average percentage of ash in the coal as shown by the coal tests. These figures were as follows:

	1914, Per Cent.	1915, Per Cent
Ashpit refuse, per cent. of coal as fired	17.60	15.90
Percentage of ash in coal as fired	13.49	12.53
Loss of coal through grates	4.11	3.37

The averages of the determinations of loss of coal as made each week from the data supplied by the coal tests and the refuse samples were as follows for the same two years: Loss of coal through grates by formula, for 1914, 4.23 per cent.; for 1915, 3.10 per cent.

If the average of the ash and heat values of the coal tests and the average of the determinations of the percentage of combustible in the refuse for a period of a year be taken and substituted in the formula to determine the coal loss for the year, the result will be quite different from the average of the weekly coal-loss determinations. This would not be so if the coal always had the same amounts of heat and ash and there was always the same percentage of combustible in the refuse, but such a condition is impossible of realization. The reason for the divergence between the average of the weekly coal-loss determinations and the loss computed by using the average values of the ash, B.t.u. and percentage of combustible in the refuse, for the year, is that the law of the loss is an exponential curve and that in different regions the exponent varies widely.

Loss of Coal Determined by Chart

In order to simplify the solution for problems of this sort, this formula has been reduced to the form of a chart (shown herewith) by means of which, if the percentage of ash, the B.t.u. in one pound of coal as fired and the percentage of combustible in the refuse be known, the loss of coal through the grates can be read off directly in percentage.

In the chart vertical lines represent percentages of combustible in the refuse, and also the calorific value per pound of the coal. The lines curving upward to the right represent the percentages of ash in the coal as found by the proximate coal test. The straight lines sloping downward to the right represent the percentages of coal lost through the grates. To solve a problem, start at the bottom of the chart with the value of the percentage of combustible in the refuse, run up vertically to the curved line representing the percentage of ash in the coal, thence run horizontally to the right or left to the vertical line representing the calorific value of the coal per pound. The position of this point relative to the straight lines sloping downward to the right will show the percentage of loss of coal through the grates.

Example: Determine the loss of coal through the grate when the percentage of combustible in the refuse is 20 and the coal has 12 per cent. ash and a heating value of 12,515 B.t.u. per lb. Start at the bottom of the chart at the figure 20, representing the percentage of combustible in the refuse, run vertically up to the curved line marked 12, representing the percentage of ash in the coal, thence run horizontally to the right to the vertical line representing 12,515 B.t.u. per lb. This point is about midway between the straight lines marked 3 and 4, which slope downward to the right and which represent the loss of coal in per cent. The loss would be read as 3.5 per cent.

What is the loss of coal through the grate when the percentage of combustible in the refuse is 20 per cent. and the coal has 22 per cent. ash and a heating value of 11,030 B.t.u. per lb.? Start as before at the bottom of the chart at the figure 20, representing the percentage of combustible in the refuse, run vertically up to the curved line marked 22, representing the percentage of ash in the coal, thence run horizontally to the right to the vertical line representing 11,030 B.t.u. per lb. This point is about one-quarter of the way between the straight lines marked 7 and 8, which slope downward to the right and which represent the loss of coal in per cent. The loss would be read as 7.25 per cent.

These problems are the same as were worked out by the formula in the foregoing. The losses as determined by using the formula were 3.48 per cent. and 7.23 per cent. respectively.

Enlarged Scale for Closer Reading

Owing to the difficulty of reading the lines at the lower left-hand corner of the chart, this portion has been drawn to a large scale in the upper left-hand corner. This part is for use where the percentage of combustible in the refuse is less than 15.

Example: What is the loss of coal through the grate when there is 10 per cent. combustible in the refuse and the coal has 12 per cent. ash and a heating value of 12,515 B.t.u.?

Using the large-scale portion in the upper left-hand corner, start at the vertical line representing 10 per cent. of combustible in the refuse, run up vertically to the curved line representing 12 per cent. ash, thence run horizontally to the left and read the reference number at the side of the chart. In this case it is 190. Now drop down to the lower left-hand corner of the chart and, starting at the same reference number, run horizontally to the right to the vertical line representing 12,515 B.t.u. per lb. This point is about midway between the lines marked 1 and 2, which slope downward to the right and which represent the loss of coal in per cent. The loss would be read as 1.5 per cent. By substituting the values in the formula, the loss will be found to be 1.54 per cent.

Editorial Courtesy

It is said that the return of a manuscript to its author may imperil the life of the Chinese editor and that only by the invariable use of the most gracious, courteous and apologetic language can he expect to avert the awful wrath of the contributor whose manuscript is declined, and save his own editorial head from swift decapitation. The following letter from a Celestial editor, accompanying the return of a manuscript, surely denotes tactfulness and a realization of the direful consequences if the recipient took offense thereat, says *Our Dumb Animals*:

Most honored brother of the sun and the moon: Your slave is prostrate at your feet! I kiss the ground before you, and implore you to authorize me to speak and live. Your manuscript has permitted itself to be looked upon by us, and we have read it with enchantment. I swear on the tomb of my ancestors that I have never read anything more exalted. It is with fear and terror that I send it back. If I allowed myself to print this treasure, the president would immediately order me to use it forever as an example, and forbid me to dare to print anything inferior. My literary experience enables me to declare that such literary pearls are only created once in ten thousand years, and this is why I take the liberty of returning it to you.

Removing the Ammonia Charge

By E. W. Miller

SYNOPSIS—How the system was quickly cleared of weak ammonia and a new charge put in in the height of a busy season.

Last summer I had occasion to remove the ammonia charge from a plant where it had become weakened and polluted with water. It was during the warmest part of the season, and the job had to be done quickly. To one who has removed the charge from a plant, it is not necessary to mention that it is pretty slow work at the best.

The greatest trouble in removing a charge in the ordinary way is that the ammonia liquid is very slow in coming down from the condenser. It seems to like to hang up there. I first made a connection to the liquid receiver from which the liquid ammonia was drawn off into empty drums as fast as it came down. The drums were placed on a scale so we could tell when they had the proper amount in them. When ready to start, I shut off the valve in the liquid line to the expansion coils on the ice tanks and pumped as high a vacuum as possible on the tanks. The liquid ammonia, as fast as it came down into the receiver, was drawn off into the drums.

Let Air Into the Steam

After I had pumped down until about 25 in. vacuum could be maintained with the machine barely turning over, only about half of the charge in the system was in the drums. The rest was coming down into the receiver very slowly. The condenser was an extra large one for the work it had to do, which made matters that much worse. When the expansion coils were apparently pumped empty, as indicated by the slow speed of the machine maintaining the vacuum, I loosened one of the flanges in the liquid line above the stop valve at the receiver and let air into this part of the system. Before I did this, I shut off the expansion valves on the tanks on all coils but one. On this coil I opened the expansion valve wide. In this way the air rushing in through the opened flange carried the dead liquor in the liquid line and in the coil ahead of it back to the compressor. After the first coil had blown for about fifteen minutes, the expansion valve on this coil was closed and the next opened.

Expansion Coils Quickly Cleaned

This procedure was followed until every coil had been blown. Then the first one was given another short blow, the expansion and suction valve closed to keep anything from backing up into it from the other coils, and the same thing was done with the other coils. In this way the expansion coils were well cleaned. This was not the only point gained. My reason for letting the air into the system was to fill the condenser with air and thus increase the condenser pressure, when I concluded the ammonia in the condenser would all condense and come down more readily. Before I opened the flange in the liquid line to let the air into the system, I went up on the condenser and shut off the liquid valve on each stand but one. In this way the flow down to the receiver was all through the one coil. As soon as this was done, the liquid in this coil came down in a rush, as shown by the gage-glass on the receiver. Soon no more came down, so I went up and shut off the liquid valve on this stand to prevent liquid from backing up into it from the other coils when the liquid valves on these were opened. Then I opened the liquid valve on the next stand, when the liquid came down quickly, as it had done with the first one. This performance was followed with each condenser stand. The condenser pressure was maintained at 210 lb. by varying the speed of the machine, and with 60-deg. condenser water there was nothing to do for the ammonia but condense, and with only one coil open at a time to the receiver, the flow into the coil forced the liquid down ahead of it. It was a simple matter to tell when a coil was clear by observing the gage-glass on the liquid receiver. After I had gone over the entire condenser in this manner once, I went over it the second time, but got little ammonia.

One Coil Purged at a Time

The expansion coils were each provided with a purge valve at the bottom and were fed from the top. As soon as all the liquid was out, the joint in the liquid line was closed and a joint in the suction header of the machine opened. In this way air was pumped through the condenser, liquid receiver and liquid line into the expansion coils. The purge valve on one coil at a time was opened and each coil blown out thoroughly. There was little ammonia in any of them as the first blowing had cleared them quite well.

In addition to getting the charge out in a hurry, nearly all the dead liquor and water was cleaned out by circulating air through the system in this manner. After all the coils had been blown, the liquid receiver was blown. Then everything was closed and as high a vacuum as possible pumped on the whole system by closing the discharge stop valve on the compressor and blowing the air out through the purge valve on the machine. Then the new charge was put in. As an indication of the thoroughness with which the system was cleaned out, a test was made of the ammonia after it had been working a week, and only a slight trace of moisture was found. After the new charge was put in, the capacity of the plant was increased nearly 30 per cent, so it did not take long to make up for the time lost in making the change.

Boilers in Argentina—British-made boilers are so generally used throughout Argentina that they are regarded as the standard, and contractors, constructors and engineers, who are practically all either Argentines or Europeans, are more accustomed to work with British boilers in their plans, construction work and operations. The British boiler is somewhat different in design and type from the American. The horsepower of the American boiler runs slightly over the rating as used in Argentina, based on the metric system of measuring heating surfaces. The metric system of measurement is legalized in Argentina and almost exclusively used. The flues on British boilers are not of a standard measurement, each manufacturer using his individual measurement.—Commerce Reports.

Annealing Steel Has for Its Object (a) completely undoing the effect of hardening, leaving the steel in its softest and most ductile condition; (b) removing any strains set up by rapid cooling, particularly if the rate is different in different parts of the piece; (c) refining the grain. For (a) and (b) it is sufficient to heat below the critical point, say to 1110 deg. F., but for (c) temperature must be raised above the critical point.—Bulletin U. S. Bureau of Mines.

Operation of an Automatic Injector

By V. R. Gage*

SYNOPSIS—An explanation of the fundamental theory of the operation of an automatic injector and data relating to the operating limits with various lifts, boiler pressures and discharge temperatures. Some experiments were made with an altered construction of the injector, and the results obtained are highly interesting.

Suppose you are running a boiler and putting water into it with an automatic injector. Ordinarily, the water comes to the tank cold, say 47 deg. F., but you fill the tank, let it stand and it gets hot, say 90 deg. The boiler pressure is 90 lb., and the injector won't work. What do you do? Throttle the steam to the injector, of course. Now look at Fig. 2. It is seen that 90-lb. steam and 90-lb. delivery are in the working range for

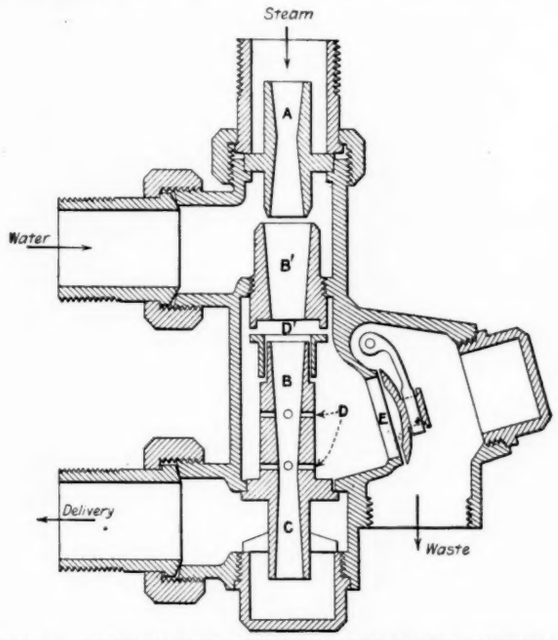


FIG. 1. SECTION THROUGH AN AUTOMATIC INJECTOR

47-deg. water, but they are outside it for 90-deg. water. Follow the 90-lb. delivery line to the left (and horizontally), and the limiting steam pressures for 90-deg. water and 90-lb. delivery are 85 lb. high and 77 lb. low. If you haven't 77 lb. on the boiler, you can't make it work anyway. Of course you must have the same suction as in this case, 16 in., which is determined by connecting a vacuum gage in on the suction pipe right at the injector. If the vacuum gage showed 8 in., then use Fig. 3. The effect of different vacuums is shown in Fig. 4. Maybe you will have to raise the tank and shorten and straighten the suction line in order to use the hot water—compare Figs. 2, 3 and 4.

With the suction, or lift, less than it used to be, consider what happens if the boiler pressure drops to 70 lb. The injector won't work. So you partly close the valve in the suction line and it does pick up. In Fig. 5 the curves show that the suction must be at least 6 in. in order to handle 47-deg. water at 70-lb. boiler pressure. If the boiler pressure drops still more, to say 60 lb., you have to throttle the suction some more—until the vacuum gage shows 9 in. The night watchman comes around in the early morning and finds the boiler pressure down to 30 lb., and he has an awful time starting the injector, also in keeping it feeding. First he has to empty the tank—56-deg. water won't work—and when the tank is filled with water at 47 deg., he has to almost close the valve in the suction line in order to have a suction of from 19.5 to 24 in. Follow the 30-lb. boiler-pressure line on Fig. 5, and you will see that the injector would be working pretty close to its limits and its action would probably be ragged.

With regard to hot water, Fig. 6 shows conditions only approximately when the steam is throttled. But it indicates that if the water is hot it is best to open the suction valve wide, perhaps to raise the supply tank, and if the boiler pressure is greater than that at the peak of the curve, to throttle the steam. If hot water is used continuously (see Fig. 10), say at 8-in. suction and above 107 lb. boiler pressure, it will be best to remove the washer.

Of course you must be using the same injector as the one used for these tests. Otherwise the pressures and temperatures would be of different numerical values, but the ideas and the directions of change would be the same. With another make, or perhaps even a change of size, the forms of the various curves would be the same, but the numerical relations probably would be somewhat different.

A diagrammatic cross-section of an automatic or restarting injector is shown in Fig. 1, where A is the steam nozzle, B the combining tube, B' a draft or suction tube, C the delivery tube, D a primary or lower overflow, D' a supplemental or upper overflow and E the waste valve on the overflow chamber.

Principle of Operation

The reason why an injector will operate is that the steam in passing through the steam nozzle has a large part of its heat energy, as well as of its pressure energy, transformed into kinetic energy, or velocity. Steam issues from the nozzle at a very high velocity and at a low pressure. The action is the same as in the nozzles of an impulse-type steam turbine. In the turbine the kinetic energy of the steam is absorbed and transformed into work by impinging upon the buckets, but in the injector it impinges upon the particles of matter in the suction space and drags them along. At first the air is drawn out of the suction line, and as the pressure is thus reduced, the atmospheric pressure forces water up into the space, and the injector begins to "pick up." Then the water is carried through the suction tube B' and most of it overflows through D', but some continues through the combining tube and overflows through D, thus getting a start toward the boiler. As soon as proper conditions for operation are established, the velocity carries the water and steam straight through the combining and delivery tubes B and C and passes the check valve in the line to the boiler. Considering the water and steam as one

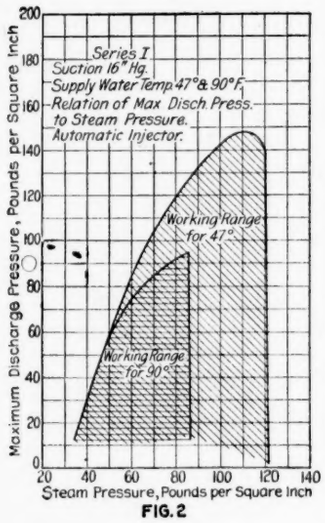
*Assistant professor, department of experimental engineering, Sibley College, Cornell University.

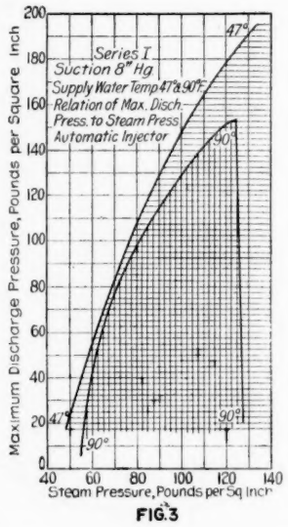
mass, there is not much change of average velocity throughout the suction and combining tubes. That means not much change in pressure from that at which the steam leaves the nozzle *A*. But in these tubes the water is condensing the steam, and this condensation should be nearly complete by the time the mass reaches the delivery tube, where the velocity of the mass is reduced, with a corresponding increase of pressure.

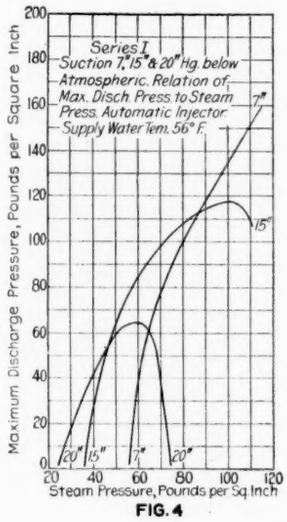
Owing to the heat energy the steam attains an enormous velocity. Enough of this velocity is imparted to the water so that when the velocity energy of the mass is properly controlled, it can be converted into a pressure greater than the original steam pressure. The process is similar to that of a steam turbine driving a centrifugal pump. In the injector the steam acts directly on the water instead of on intermediate pieces of metal. Of course, in this direct action the efficiency of transfer of impact energy is not as great as with properly designed turbine buckets and water impellers, although in the injector practically no heat is lost.

The pressure existing through the suction and the combining tubes is nearly the same as that of the steam issuing from the nozzle. The rate of condensation of the steam through the suction and the combining tubes is such that the reduction in volume of the combined mass is nearly equal to the reduction in area of the tubes, so the average velocity of the combined mass through the tubes is nearly constant. Hence the kinetic energy and pressure throughout the suction and combining tubes is nearly constant, and therefore the condensing of the steam has no direct effect on producing a vacuum in the suction pipe. It has an indirect effect only in that it must proceed within certain limits for a given taper of the tubes, or the injector will not work. The vacuum in the suction pipe is a function of (1) the steam pressure, (2) the efficiency of the steam nozzle in expanding the steam, and (3) of proper entrance conditions for avoiding shock and cross-currents.

There result two distinct kinds of breaking, or unsatisfactory operation. When the steam condenses faster than the taper of the tube, then the velocity of the combined mass decreases with a consequent building up of pressure. If the pressure builds up equal to or greater than atmospheric pressure at the main overflows, there will be a dripping or steady stream of water discharged, but without fuss. This happens with too low steam pressure or with the suction-line valve too wide open or with too cold water.


Series I
Suction 16" Hg.
Supply Water Temp. 47° & 90° F.
Relation of Max. Disch. Press. to Steam Pressure.
Automatic Injector.
Working Range for 47°
Working Range for 90°
Maximum Discharge Pressure, Pounds per Square Inch
Steam Pressure, Pounds per Square Inch
FIG. 2


Series I
Suction 8" Hg.
Supply Water Temp. 47° & 90° F.
Relation of Max. Disch. Press. to Steam Press.
Automatic Injector
47°
90°
Maximum Discharge Pressure, Pounds per Square Inch
Steam Pressure, Pounds per Sq. Inch
FIG. 3


Series I
Suction 7", 15" & 20" Hg. below Atmospheric. Relation of Max. Disch. Press. to Steam Press. Automatic Injector.
Supply Water Tem. 56° F.
7"
15"
20"
Maximum Discharge Pressure, Pounds per Square Inch
Steam Pressure, Pounds per Sq. Inch
FIG. 4

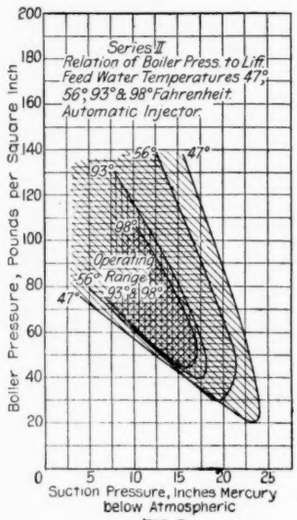
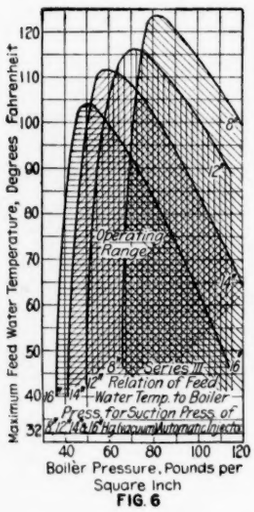
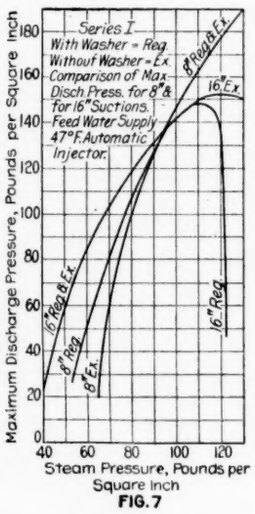
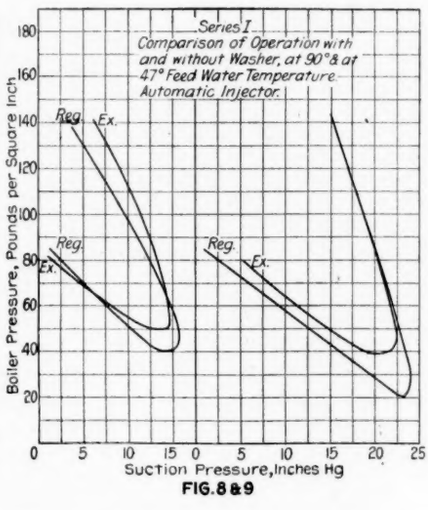
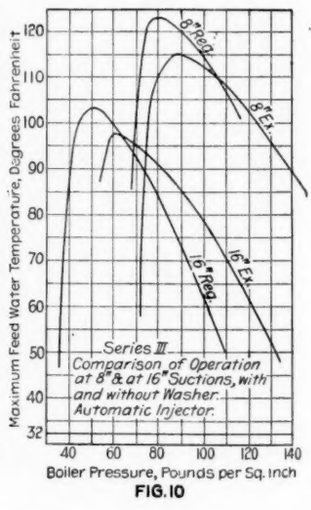


FIG. 5


Series III
Relation of Feed Water Temp. to Boiler Press. for Suction Press. of
Operating Range
Maximum Feed Water Temperature, Degrees Fahrenheit
Boiler Pressure, Pounds per Square Inch
FIG. 6


Series I
With Washer = Reg.
Without Washer = Ex.
Comparison of Max. Disch. Press. for 8" & for 16" Suctions.
Feed Water Supply 47° F. Automatic Injector.
8" Reg. & Ex.
16" Reg. & Ex.
8" Reg.
8" Ex.
16" Reg.
16" Ex.
Maximum Discharge Pressure, Pounds per Square Inch
Steam Pressure, Pounds per Square Inch
FIG. 7


Series I
Comparison of Operation with and without Washer, at 90° & at 47° Feed Water Temperature.
Automatic Injector.
Reg.
Ex.
Boiler Pressure, Pounds per Square Inch
Suction Pressure, Inches Hg
FIG. 8 & 9


8" Reg.
8" Ex.
16" Reg.
16" Ex.
Series III
Comparison of Operation at 8" & at 16" Suctions, with and without Washer.
Automatic Injector.
Maximum Feed Water Temperature, Degrees Fahrenheit
Boiler Pressure, Pounds per Sq. Inch
FIG. 10

FIGS. 2 TO 10. CURVES OF THE WORKING LIMITS OF AN INJECTOR, WITH DIFFERENT STEAM PRESSURES, DISCHARGE PRESSURES, SUCTION PRESSURES AND WATER TEMPERATURES

When the steam does not condense fast enough for the taper of the tube, it is possible that in order for the combined mass to go through the opening, it would have to travel at a velocity greater than possible with the energy supplied. As the mass cannot all get through the smallest portion of the tube, and as it is continuously coming in, a pressure is built up. In this event steam issues, with violence, from the overflow pipe. The steam pressure at times also breaks the vacuum so that the lifting of water is intermittent. This second class of breaking is perhaps more common and is caused by too much steam due to too high steam pressure, too hot water or too much throttling in the suction line.

Rate of Condensation Important

The main factor to consider in this type of injector is the rate of condensation of the steam. This rate is controlled by three factors—the quantity of steam, the quantity of water and the temperature of the water. The quantity of steam flowing through the nozzle is dependent upon the steam pressure. The quantity of water is dependent upon the height it has to be lifted, because the energy available for lifting the water (with a given steam pressure) is nearly constant, so if the head is increased then the weight is reduced, for the work done is the product of weight and head.

Consider a given mass of steam and water entering the suction tube. As it passes along through this tube, the steam is condensing, so the volume occupied by this mass is continually growing smaller. But the tube is also growing smaller in cross-sectional area. If the reduction of volume of this mass is the same as the reduction in area of the tube, then the velocity of the mass is the same and there is no pressure change. The same statement applies to the mass as it continues through the combining tube. But in this injector there is a washer or sleeve or collar or some kind of a valve seat which rises and closes the upper overflow space D' (Fig. 1). In order for this washer to rise some motive power must be supplied, by having the pressure at the lower overflow D greater than the pressure at the upper overflow D'. Hence the reduction of volume of the mass may be greater than of the area of the tubes, thus decreasing the velocity and transforming some kinetic energy into potential energy. But the pressure at the overflows D and D' cannot become greater than the atmospheric pressure, or the overflow valve E would lift and the injector "break."

Variables Affecting Operation

When the injector is feeding the boiler from which it draws steam, there are three variables—the steam pressure, the suction pressure and the supply-water temperature (neglecting the condition of the steam supply). If the injector does not draw steam directly from the boiler that is being fed or if the steam supply is throttled, then a fourth variable is introduced—the discharge pressure.

It should be borne in mind that the limits here shown are the limits to which the injector would "hang on," starting from good working conditions and gradually changing one variable until the "break" occurred. An injector will often hang on and continue to operate with conditions existing under which it would fail to pick up or start.

Steam pressures in the diagram are given in pounds per square inch gage, the suction pressures in inches of mercury below atmospheric pressure and the temperatures in Fahrenheit degrees.

Series I was made with four variables. The temperature of the feed water and the suction pressure were maintained constant, and the maximum discharge pressure for satisfactory operation was determined for each value of steam pressure covering the range limited by the minimum steam pressure at which the injector would operate and the maximum pressure obtainable (or at which the injector would work). For a lift equivalent to 16 in. mercury the effect of feed-water temperature is shown in Fig. 2. The colder the water the greater the maximum discharge pressure obtainable with a given steam pressure. The effect at low steam pressures is not noticeable. Also the maximum operating steam pressure is greater with colder water; this effect is more completely shown in Fig. 5. The same results are shown in Fig. 3, which is for the same water temperatures, but a suction pressure of 8 in. For a constant feed temperature the relations of steam and maximum discharge for several suction pressures are shown in Fig. 4. The range of operation is much less for the greater lifts, and the maximum pressures are also much less.

Series II and III were made with three variables, the discharge pressure being always kept the same as the steam pressure. In speaking of the steam-delivery pressures the term boiler pressure will be used.

Maximum and Minimum Lifts

Series II was the determination of the maximum and minimum lifts for each of several boiler pressures. In Fig. 5 each curve shows this relation for a different temperature of water. The area inclosed between any of the curves shows the operating range for that temperature of supply water. The lowest boiler pressure which can be used with a given lift is not much affected by the temperature of the feed, but for a given vacuum the hotter the feed the lower the maximum boiler pressure. Also, as the feed water becomes hotter the injector cannot lift it so far as when cold, no matter what the boiler pressure is.

Series III was the determination of the maximum temperature of water supply at each of several values of boiler pressure, suction pressure maintained constant, then repeated for other constant suction pressures, as shown by the curves on Fig. 6. The greater the lift the colder the water has to be, as mentioned in Series II. The maximum temperature for each suction pressure decreases with increase of suction and is obtained at lower boiler pressure for greater suctions. The curves cross each other, as would be expected from Fig. 5. As a matter of fact, Fig. 6 could be plotted from Fig. 5 or vice versa, if there were enough curves on either. For a given suction the maximum temperature that can be handled rises rapidly from the lowest boiler pressure until it reaches an ultimate maximum, and then as the boiler pressure increases, the maximum supply temperature that can be used gradually decreases.

Curiosity as to the real value of the sleeve washer which sometimes rises and closes the upper overflow D', Fig. 1, led to its removal. The function of this device is to prevent return circulation from D to D' through the overflow chamber when the rate of condensation of

the steam in the combining tube is greater than the reduction in the area of the tube. When, because of low steam pressure, cold water or water supply under pressure, this condition exists, then the velocity of the mass grows less as it flows through the combining tube, and some of the kinetic energy is transformed into potential, or pressure, energy. As long as the pressure at the primary overflows *D* does not exceed the pressure of the atmosphere, the injector will not break. A hand-operated valve may be placed on the waste pipe, and when closed, the injector will operate under more adverse conditions, but it then ceases to be restarting until this valve is opened.

In all these tests the delivery pressure was maintained by opening or closing a small-sized valve. The injector was started with this discharge valve open. It is probable that this feature enables the injector to start with conditions under which it ordinarily would not, as part of the water can establish a movement through the tubes, an impossibility when connected to the boiler.

Series I was repeated with the washer removed. In Fig. 7 the results thus obtained are marked *"Ex,"* and for comparison the curves for the same feed temperature and suction pressures from Figs. 2 and 3 are reproduced and marked *"Reg."* The removal of the washer has little or no effect up to 130 lb. steam pressure at 8 in. suction. For 16 in. suction the removal apparently increases the maximum limit of steam pressure. So far as these limits are concerned, little difference is shown.

Similar comparison is made of Series II with and without washer in Figs. 8 and 9. Fig. 8 with hot feed water shows that the maximum boiler pressure is greater without, but that the greatest lifting power and minimum boiler pressure are obtained with the washer. For cold water Fig. 9 shows little or no difference on the upper limit of boiler pressures, but an increased range with the washer for the lower boiler pressures and also a greater lifting power.

Series III is shown in Fig. 10. The ultimate allowable maximum feed temperature is greater with than without. For higher boiler pressures hotter water can be handled without the washer than with.

In addition to the foregoing, a Series IV was made showing the variation of capacity with feed-water temperature, maintaining constant steam-delivery pressure and a constant lift. There is a possible exceedingly small reduction in capacity when the washer is removed. This apparent reduction is so small that it may be due to experimental errors. All these data are compiled from student observations. Excepting Series IV, all were carefully supervised with the active assistance of the writer.

With the washer removed these series were again repeated, this time with all the primary overflow holes *D* plugged. The inside of the tube was not altered by the plugs extending in. This caused the injector to be exceedingly "cranky" and hard to start. The operating limits were in all cases reduced with the exception that hotter water can be handled at higher boiler pressures than in either of the cases cited.

The primary overflows are essential for satisfactory operation and good capacity. The washer closing the upper overflow evidently is not.

Steam-Engine Troubles—Governors—II

By H. Hamkens

SYNOPSIS—Varying the speed of engines by adjustment to, and changes in, governors. Good and bad features of different forms of governor drive. Obtaining equal cutoff at both ends of the stroke. Care and troubles of safety stops.

It is often desirable to change the speed of an engine, and if the change only amounts to two or three revolutions a minute, a lever and weight can be added, as shown in Fig. 116. If arranged as shown in full lines, the speed of the engine will be decreased, and if as in dotted lines, it will be increased. A large weight on a long lever, as shown in Fig. 117, making a considerable change of speed possible will render a governor sluggish and its action uncertain on account of the inertia of the parts. A spiral spring will give better results; it must be located in a central position to the governor, as indicated in Fig. 118. Attaching a heavy weight or a spring to the side of the sleeve or to the governor lever will increase the friction and make its action unreliable. If the speed of an engine is to be permanently changed, say ten or more revolutions per minute, it will be advisable to change the governor pulley, making it larger in diameter for higher speeds and smaller for slower. A change in the ratio of the gears will give the same result. Change of speed by means of frictional drives using conical pulleys or friction disks should be used only in extreme cases where the variation in speed amounts to 40 or 50 per cent.

There are more belt drives in use on Corliss-engine governors than all other drives combined, in spite of the fact that every designer and engineer knows the shortcomings of a belt. It will stretch, break, slip, run off, run crooked, get soaked with oil, etc.; still, we find it in use on almost every engine. The reasons for this are that it is cheap, noiseless, easily put on and repaired; it is always in plain view and can be watched and replaced if it shows signs of weakness. At the same time it is a constant source of worry.

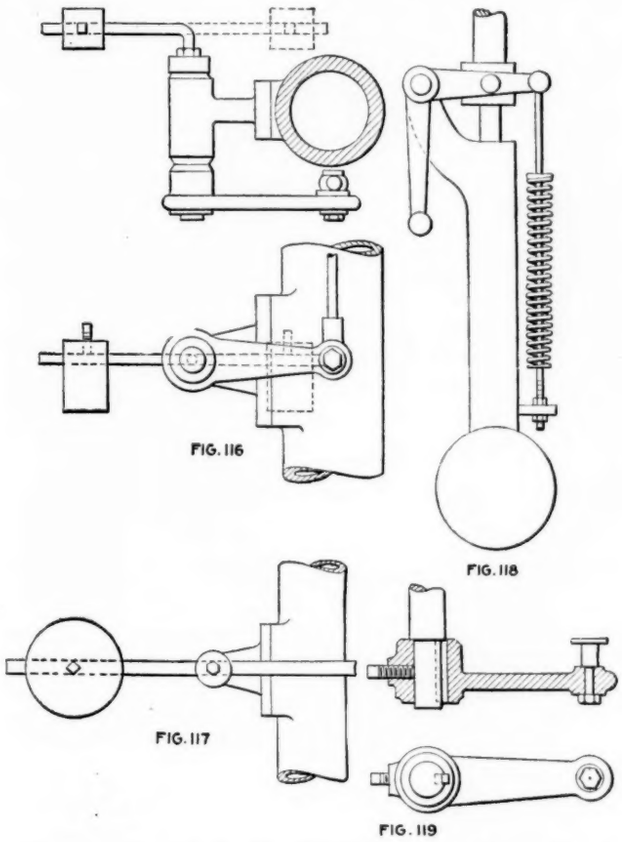
Gear drives came into use some years ago, but most of them have been discarded. They were expensive, required a lot of lubrication, the bearings ran hot, the babbitt would wear out and the teeth of the driving gear on the main shaft would break.

On some large engines, where the distance between the mainshaft and the governor is considerable, ropes are used, generally three of them. They are, of course, never of the same length and have not the same tension—one rope will do most of the driving while the others do hardly any work. If a rope gets too slack, it must be respliced, which requires considerable skill. If carelessly done every time a splice runs over the sheave there will be a jerk on the governor, causing an irregular speed.

Silent-chain drives are in use on some engines that require close regulation. They must be carefully covered to prevent dirt getting into the chain; if anything gets out of order the engine may be thrown out of service for quite a while. It is advisable to have spare parts of the

chain and extra sets of chain wheels on hand, to be prepared for an emergency.

The trouble with some belt drives for governors is that the belt is of inferior quality, of insufficient width, or the governor pulley is too small. On many engines the governor belt runs directly on the main shaft, but for high-speed governors a pulley is used, which must be



FIGS. 116 TO 119. WEIGHTS FOR ENGINE GOVERNORS

Fig. 116—Small weight gives slight speed change. Fig. 117—Too Heavy weight; makes governor sluggish. Fig. 118—Spring used instead of weight. Fig. 119—Good fastening for governor levers

well secured. If it ever becomes loose and slips, there may be just enough friction between shaft and pulley to keep the governor revolving, preventing it from throwing in the safety-cams, but admitting more steam than is required, making the engine speed up and perhaps run away. A double leather belt should be used, not less than 3 in. wide. It must be endless, even and tight, without metal joints or lacing, and it must be kept free from oil.

Considerable trouble is experienced with governor levers, gears and pulleys coming loose; all of these parts must be secured in the most approved manner. It is best to use two ways of fastening, so that if one should fail the other will insure safety. A poor way to hold a lever on a shaft is by means of a taper pin; next to that is the use of only one setscrew. Fig. 119 shows a good way to fasten governor levers, by a feather and a cupped, case-hardened setscrew. The same method is used in Fig. 120 to hold the governor pulley securely on its shaft. As an extra precaution, a washer with stud and nut keeps the pulley from working off. A driven key may be used in the pulley hub, in which case a cap should be provided, held in place by a stud and nut to prevent the key getting loose and to protect the attendant from being caught by the key. Fig. 121 shows an approved way of holding the gears on the shaft and spindle. Feathers and setscrew together are also employed, the driven gear being placed below, which is the safest position for it.

The stub ends of governor rods should have about $\frac{1}{32}$ in. play on each side, as shown in Fig. 122; under no circumstances should they fit tight between the lever and the head of the pin. The lift of a flyball governor is usually limited by a collar on the spindle, as shown in Fig. 123. This collar must be placed high enough so that the governor cams will trip the valve gear and prevent steam entering the cylinder with the sleeve or weight touching the collar. A setscrew let deep into the spindle and screwed up tight should secure the collar; if it slips down and keeps the governor from rising to the highest position, the chances are that the engine will run away on a light load.

All the parts which connect governor and valve gear must be as light as is consistent with safety; therefore, of the arrangements shown in Fig. 124, the one marked *A* is the better. The double lever in *B* makes the upper rod in some engines long and heavy. It may begin to vibrate and interfere with the cutoff on the head end. If the rod is so long that it will sag even if made of a piece of pipe, it must be cut in two and supported by a carrier, thus increasing the friction.

Especial care should be used to locate the pins in the cam levers in such positions that cutoff at both ends of the cylinder is equal for any load, or at least as near so as the angularity of connecting-rod and eccentric rod will allow. For equal cutoff the crankpin travels through a greater arc on the crank end than on the head end. In Fig. 125 the arcs are shown for one-quarter cutoff. The difference in travel should be compensated in the valve gear and setting of the governor-cams. Using the ordinary rocker arm of a single-eccentric engine and an angular advance of about 7 deg. for the eccentric, the positions of the rocker arm show that here the conditions are reversed in relation to the piston travel. In other words, the rocker arm moves slowly with the piston moving fast at the head end and it moves fast with the piston moving slowly at the crank end; provided, of course, that the

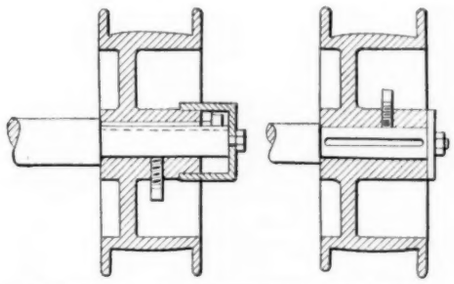


FIG. 120. METHODS OF FASTENING GOVERNOR PULLEY

motion of the crankpin is uniform. The cam on the head end should, therefore, be made to travel through a greater arc for a given cutoff than the one on the crank end.

The usual way to lay out valve gears is to assume that the angles through which the crank and eccentric travel are alike for equal cutoff, and it keeps an engineer guessing why he has to change the governor rods almost every time he indicates the engine, in order to equalize the load at both ends of the cylinder. Unless the angularity of the connecting-rod and eccentric rod is taken into account, the ordinary Corliss valve gear will give equal cutoff for

only one position of the governor, that being the one for which it is adjusted by blocking. For all other positions the cutoff at both ends of the cylinder will be unequal. If an engineer will go through all the phases of indicating his engine, from the latest cutoff to the earliest by lifting the governor one-quarter inch at a time and blocking it, he will get an instructive set of diagrams. Trying to equalize the cutoff on an engine without blocking the governor is of course useless unless the load is steady.

On cross-compound engines trouble with the regulation may be caused by friction in the bearings of the cross-shaft. Even if this shaft be made of a piece of pipe, there will be a certain amount of deflection. The bearings should therefore have spherical seats so they can adjust themselves. Fig. 126 shows a simple arrangement that may be used to advantage on both sides of a cross-compound engine. The spherical part of the bearing gives it a chance to accommodate itself to defects of the cross-shaft due to deflection or bad alignment.

Unequal distribution of the load on the two cylinders of compound engines is often very troublesome. It is generally due to faulty construction of the governor levers. Referring to the two diagrams in Fig. 127, showing the combined cards of a compound engine, *A* indicates that the high-pressure cylinder carries a greater load than the low-pressure. To equalize the burden the cutoff in the low-pressure cylinder must be shortened, which will raise the receiver pressure and distribute the load equally, as shown in diagram *B*. The simplest way to accomplish this is to lengthen the governor lever on the low-pressure side.

The levers shown in Fig. 128 will answer the purpose. One of them has a number of holes drilled in the end; the pin can be changed from one hole to another to raise or lower the receiver pressure. A more accurate adjustment can be made with the other lever, which has a slotted end provided with a screw and handwheel. The position of the pin on this one can be changed gradually without disconnecting the rod. If a double lever be used, the adjustment must be on both ends. The same result is sometimes obtained by moving the low-pressure governor lever ahead or back without changing its length, which can be done by an arrangement shown in Fig. 129.

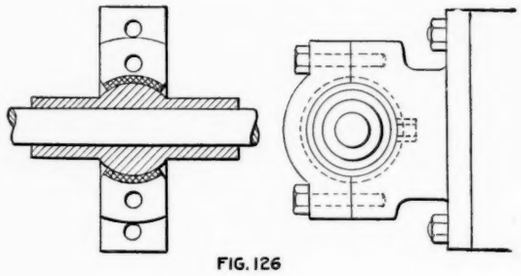


FIG. 126

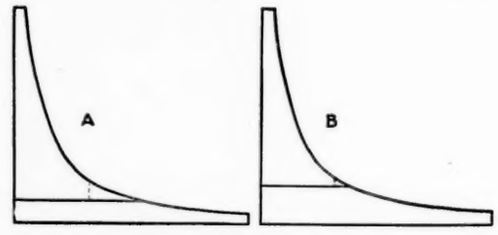


FIG. 127

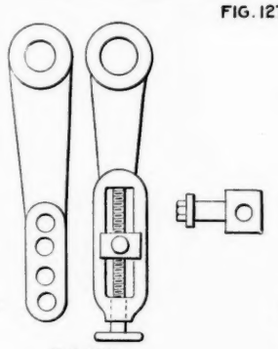


FIG. 128

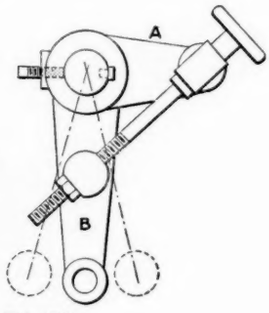


FIG. 129

FIGS. 126 TO 129. MORE PARTS OF ENGINE GOVERNORS

Fig. 126—Good form of bearing for governor cross-shaft of compound engine. Fig. 127—Combined indicator diagrams. Figs. 128 and 129—Cutoff adjusting devices

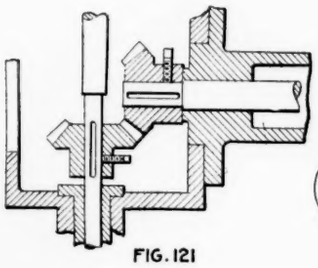


FIG. 121

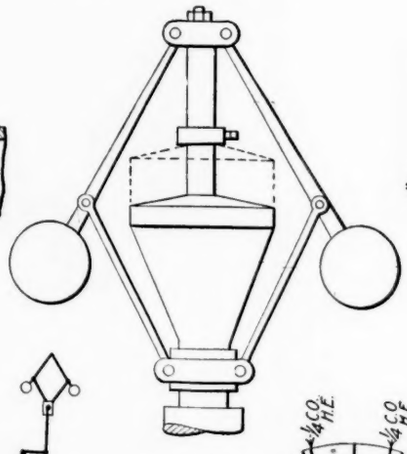


FIG. 123

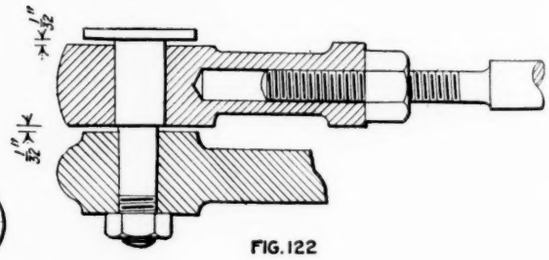


FIG. 122

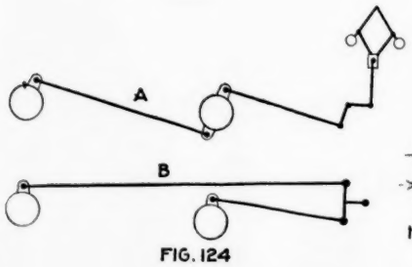


FIG. 124

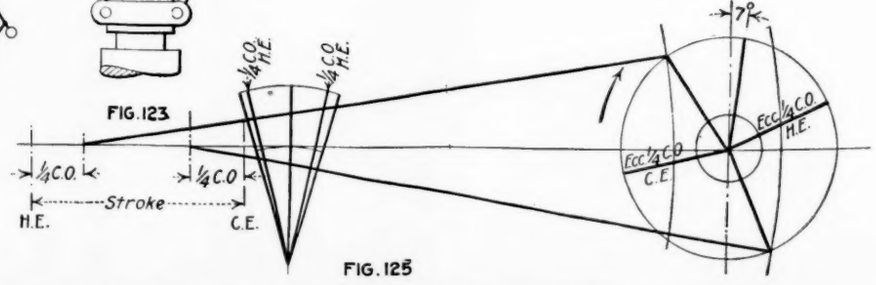


FIG. 125

FIGS. 121 TO 125. CONNECTIONS FOR GOVERNORS OF STEAM ENGINES

Fig. 121—Approved gear fastenings on shaft and spindle. Fig. 122—Stub ends of rods should never fit tightly. Fig. 123—Be sure the collar is high enough to trip the valve gear. Fig. 124—Of the two, A is the better arrangement. Fig. 125—The arcs are for one-quarter cutoff

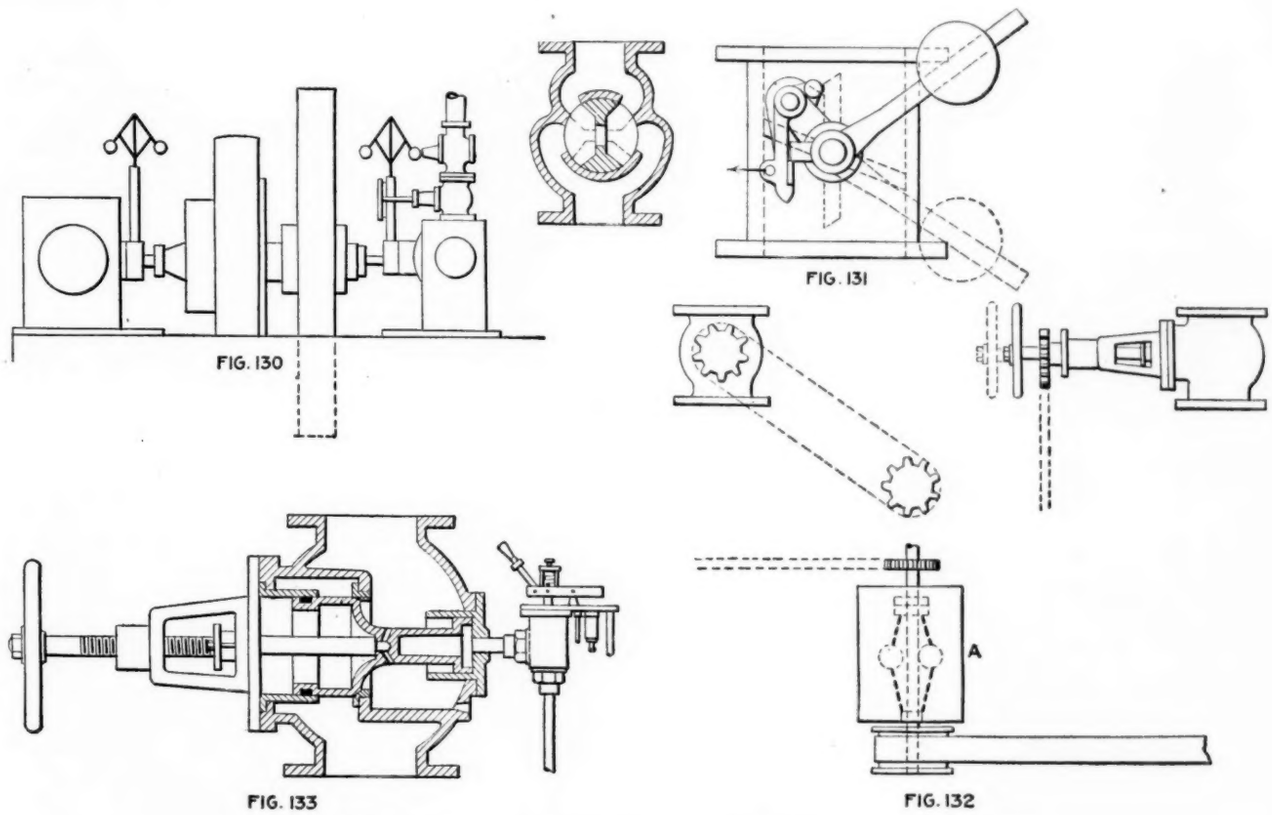
There are two levers used in this case. *A* is secured on the shaft, while *B* is loose and adjusted for position by means of a screw. For the greatest possible refinement this device is sometimes furnished with a slotted end on the loose lever.

It must always be understood that a governor will regulate the speed of an engine only if everything is in working order, and it is the engineer's business to keep it so; but even the most untiring care and vigilance cannot prevent the breaking of a stub end or rod, slipping of the belt, breaking of levers and pins and other accidents, which will endanger life and buildings. It seems, therefore, that one governor alone should not be relied on, but that the engine should be provided with a second device which would act and prevent it from running away if the regular governor should fail.

Fig. 130 shows a cross-compound engine with two governors—the one on the low-pressure side to regulate the cutoff of the engine and the one on the high-pressure side to operate an emergency valve (which is shown in detail) should the engine exceed its normal speed by from five to ten revolutions. The second governor will pull a latch on the stem of the emergency valve, releasing a weight which will close the valve and shut off steam from the engine. This valve can also be closed instantly by hand if the necessity should arise. Instead of the emergency valve shown, a butterfly valve provided with a weight and tripping device may be used, as shown in Fig. 131. Neither of these is steam-tight, but when closed they will stop the engine. Care must be taken not to have the stuffing-box for the valve stem too tight, or the weight may not be sufficient to close the valve.

Fig. 132 shows an arrangement in which a sprocket chain is made to turn a wheel on the valve stem and close the throttle as soon as the speed limit *A*, which is a small governor, throws in a clutch. The power to do this work is derived either from the crankshaft by means of a belt, or from a heavy weight which has to be wound up by hand. This device is liable to get out of order, especially if the valve stem works tight. To overcome the trouble with tight valve stems is the object of some designs. Fig. 133 shows one in which the steam pressure is utilized to close the throttle quickly in case of emergency. The throttle-valve stem is not rigidly connected to the valve. As soon as it is screwed back the steam forces the valve open; it enters also through the small holes and fills the space above the valve. Steam also passes the small piston, which is slightly less in diameter than the bore of the little cylinder that is connected to an auxiliary valve operated by a trip-lever. As soon as this lever trips the auxiliary valve, the steam behind the small piston escapes, throwing the main valve out of balance, closing it. The trip-lever may be operated by an auxiliary governor set for a certain speed, by an electro-magnet or by hand. Or an old engine valve, as shown in Fig. 134, may be placed right over the throttle valve. It has the same tripping device as the one in Fig. 133 and is operated on the same principle. It is opened by a small handwheel which works a pinion and a rack, the latter being cut into the valve stem.

Complications and intricate devices on these valves should be avoided; everything must be handy for the engineer and arranged so that he can quickly shut off the steam in case of emergency. The throttle-valve hand-



FIGS. 130 TO 133. OVER-SPEED PREVENTION DEVICES FOR STEAM ENGINES

Fig. 130—Cross-compound engine with two governors. Fig. 131—Weighted butterfly valve that will trip and close. Fig. 132—Stop valve operated by flyball governor. Fig. 133—Steam pressure operated trip on throttle valve

wheel of a Corliss engine is located in the most dangerous position if an engine runs away. It takes a man of iron nerve to step into the pass of the flywheel to shut off the steam by turning the handwheel of a slow-closing throttle. Means should therefore be provided for shutting off the steam from both sides of the cylinder and from certain places inside and outside of the engine room; and

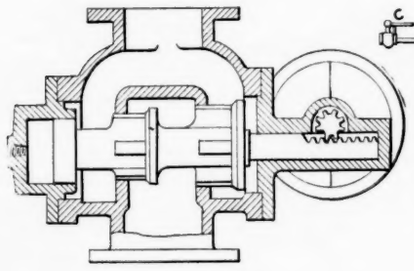


FIG. 134. ANOTHER TYPE OF QUICK-CLOSING VALVE

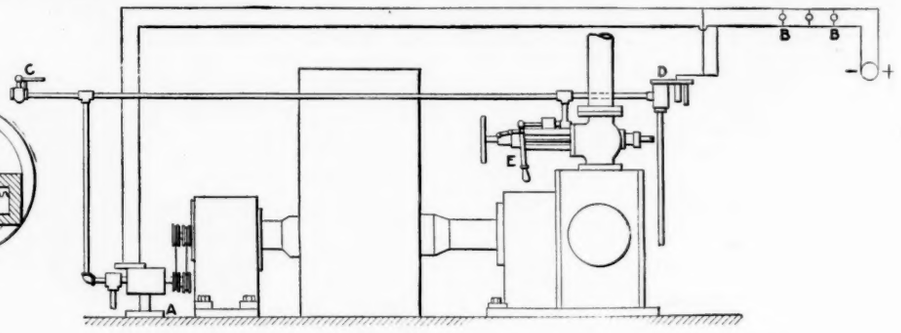
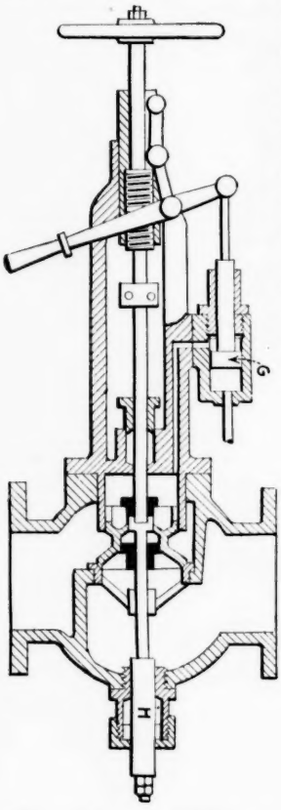


FIG. 135. DIAGRAMMATIC LAYOUT OF EMERGENCY ENGINE STOPS

besides, there should be an automatic device that will stop the engine if the speed exceeds five or ten revolutions above the normal. A complete arrangement which will accomplish this is shown in Fig. 135, consisting of a steam, electric and hand-operated system. The methods of operation are as follows: The speed-limit device *A*, which consists of a small governor inclosed in a cast-iron dustproof case, and driven by chain, ropes or belt from the end of the mainshaft, opens a small relief valve and makes electrical contact as soon as a certain speed



SEC. 136. SECTION OF QUICK-CLOSING VALVE (FIG. 135)

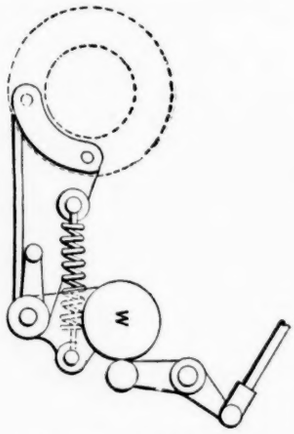


FIG. 137. EMERGENCY STOP CONNECTED TO CROSSHEAD

is exceeded. Steam is exhausted from one side of the small piston *G*, in Fig. 136, which shows the throttle valve in detail; this snaps the toggle links and trips the valve, which is closed by steam acting on the plunger *H*. The same result can be obtained by closing any one of the switches *B*, located in convenient places in the engine room, or by opening hand relief valve *C*, also by tripping the valve *D* by hand or throwing over hand lever *E*. The throttle can also be closed by the handwheel, independent of the tripping devices.

With this or a similar system the engineer should make it a practice to test the apparatus when stopping the engine, for if anything is allowed to get out of order the whole thing may become useless. There is such a thing as overdoing it, and unless a man has the time and skill to attend to all these devices, the simpler methods described are to be preferred.

Fig. 137 shows a simple speed-limit device which may be connected to the crosshead. The weight *W* is held in position by a spring. When the engine exceeds a certain speed, the inertia of the weight will make it fly ahead at the end of the stroke and strike a lever connected to the governor, tripping a latch and releasing a spring, which will force the governor to its highest position and prevent steam entering the cylinder. The trip-rod of this device can be connected to a self-closing butterfly valve or some of the other safety devices.

[*The next article treats of various designs of releasing valve gears.*]

Roughening Gasket Surfaces

By Morris Ellison

A pump had given considerable trouble by blowing out gaskets on the water end. It was desired to use graphite on one side of these gaskets, so that the heads and caps could be removed and replaced without spoiling the gaskets; therefore the water-end heads, cap and valve plates were roughened by bolting to the faceplate of a lathe and taking a light cut on the gasket face with a diamond-point tool.

No graphite is used on this rough surface, but the other side of the gasket is well covered so that the gaskets stick to the rough surface and the slight corrugations keep them from blowing out, while the other face parts from the smooth pump body and will go back perfectly tight and may be used a good many times before it needs renewing.

The Name Nickel Silver naturally creates the impression that this light-colored metal is an alloy of nickel and silver, particularly when employed for articles of tableware manufactured by the silversmith. It contains, however, no silver, and even of nickel there is not more than 25 per cent., the remaining components being copper and a little less zinc. To what an extent the presence of nickel imparts its color to the alloy may be realized by an inspection of the five-cent piece which contains 25 per cent. nickel and 75 per cent. copper, yet shows no trace of the deep color of the large copper content.—"The Metal Industry."

The Electrical Study Course—Elements of Electricity—I

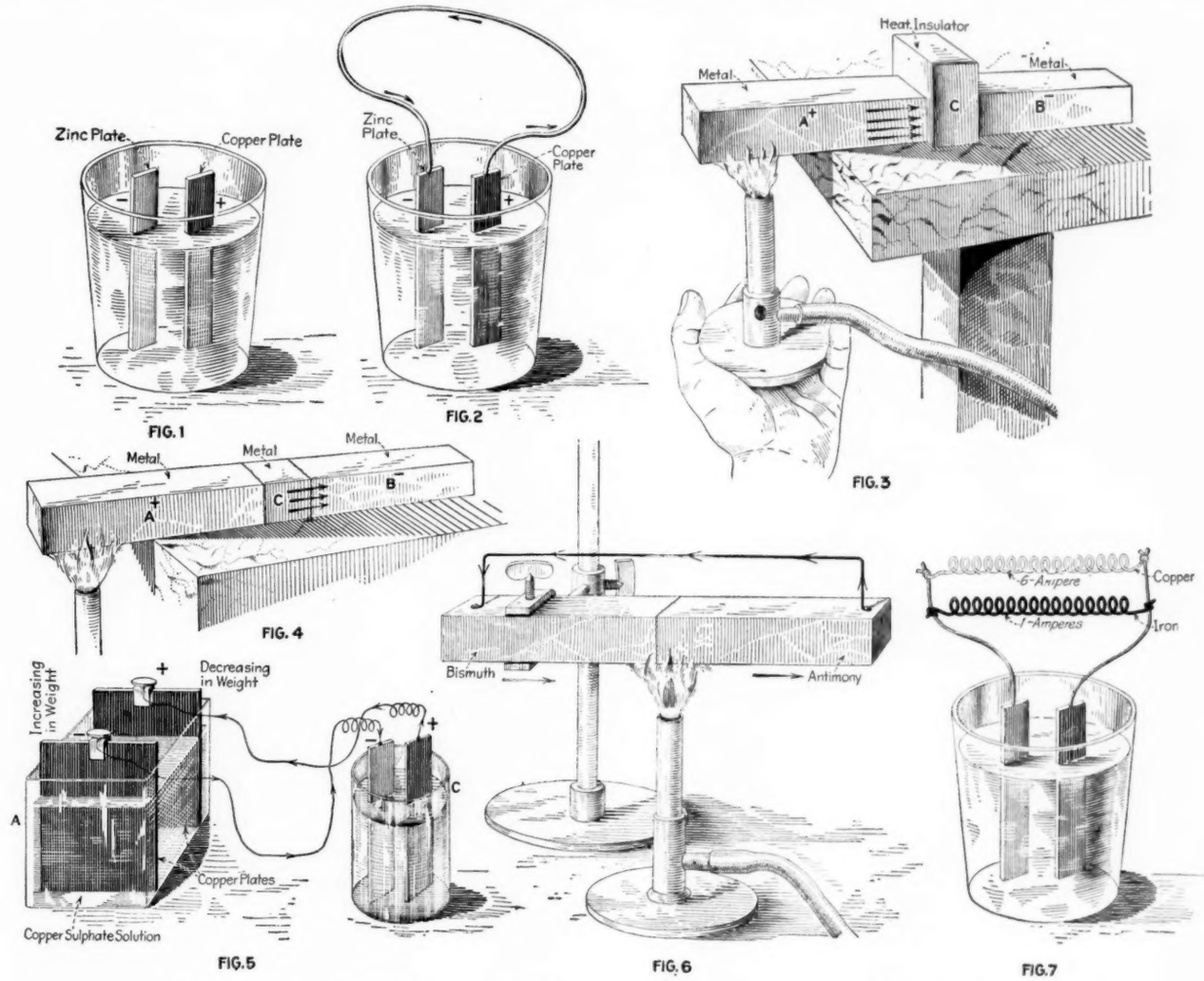
SYNOPSIS—The first of three lessons on the elements of electricity. In this one electrical pressure, current and resistance are compared with temperature, heat flow and resistance.

Electricity is an invisible agent that manifests itself in various ways, and as pointed out in the introductory lesson, it is in many ways similar to heat, light and sound. Although we do not understand the true nature of electricity, many of the laws that govern its production and application are thoroughly understood, and by the application of this knowledge very efficient electrical equipment is designed and constructed.

If a copper and a zinc plate are placed in dilute sulphuric acid, as shown in Fig. 1, a difference of electrical pressure will exist between them; that is, a current of electricity will tend to flow from the copper to the zinc plate. The terminal that the electric current tends to flow from is called the positive and is indicated by a plus sign (+); the terminal that the current tends to flow to is called the negative and is indicated by a minus sign (—). In other words, the positive terminal is at a higher potential than the negative. A device like that shown in the figure is called a voltaic cell or, as it is often referred to, a primary battery, of which there are a great many types as will be seen when this part of the subject is considered.

One thing to be noted in the voltaic cell is that an electric current was not caused to flow; all that was created was a tendency for a current to flow from the positive to the negative terminal, or from the copper to the zinc plate. This electric pressure, or difference of potential, is expressed in a unit called a "volt," after Alessandro Volta, an Italian scientist, who discovered the voltaic cell. This cell is sometimes called a galvanic cell, after Volta's contemporary, Alvosio Galvani. If the terminals of the cell are connected through a copper wire or other conducting material, as shown in Fig. 2, an electric current will flow as indicated by the arrows.

An analogy of this difference of electric pressure is found in heat. If we wish heat to flow from one body into another, a difference of temperature and also a path for the heat to flow must be provided. For example,



FIGS. 1 TO 7. COMPARE THE FLOW OF ELECTRICITY WITH THE FLOW OF HEAT

consider the conditions in Fig. 3. Here are two metal blocks, *A* and *B*, with a heat insulator *C* between them such as a firebrick or asbestos block. If heat is applied to the block *A*, as shown, its temperature will be increased above that of block *B*, or it might be said that a heat pressure exists between blocks *A* and *B*, just as an electric pressure existed between the copper and the zinc plate in Fig. 1; but on account of the insulation between the positive and negative terminals, which in this case is air, no current can flow. Likewise, in Fig. 3, a difference of temperature or heat pressure exists between *A* and *B*, which is expressed in deg. F. or deg. C. above or below a certain point, but no heat can flow into *B* because of the insulation between it and *A*.

If, now, we remove the insulating block and replace it by a metal block, as in Fig. 4, heat will be conducted from *A* to *B*, just as an electric current flowed from the copper to the zinc plate in Fig. 2, when they were connected by a metal wire. It can hardly be said that one is any more mysterious than the other, and in fact we do not know any more about the true nature of one than the other. According to the electron theory of conduction in metals, the same thing takes place in both cases; that is, there is a flow of electrons from the point of high potential to that of the lower pressure. A discussion of this subject is outside the purpose of this study course; suffice it to note the close analogy between heat and electricity. Another thing is, materials that offer a high resistance to the flow of heat also offer a high resistance to the flow of electricity.

The Unit of Electric Current

The strength of an electric current is measured by the unit called an ampere, after a French scientist, André Marie Ampère. In the case of the heat flow from one body to the other, the quantity is measured in British thermal units (B.t.u.). When an electric current is passed through certain salt solutions, it will carry the metal from the terminal in the solution by which it enters and deposit it on the one by which it leaves. In Fig. 5 is shown a voltaic cell *C*, connected to two copper plates in a copper-sulphate solution *A*. The current in flowing from the plate marked plus, will carry some of the copper from this plate and deposit it on the negative plate; that is, the positive plate will become lighter, and the minus plate will increase in weight. This is what is done to determine the standard unit of current, only silver plates are used in a nitrate of silver solution. The electric current flowing is said to be of one ampere value when its strength is sufficient to deposit 0.001118 gram of silver per second on the negative plate. Therefore it will be seen that there is nothing more difficult about this unit of electric current than there is about the unit of heat (B.t.u.), which is the heat necessary to raise the temperature of one pound of water one degree F.—to be more accurate, from 39 to 40 deg.

All substances offer a certain amount of resistance to the flow of heat, or in other words tend to prevent the heat from flowing from one part of a body to another. For example, in Fig. 4, when the metal block was placed between blocks *A* and *B*, it was assumed that the heat would flow from *A* to *B* readily. In the case of Fig. 3, it was said that if a block of asbestos or firebrick was placed between the metal blocks, very little heat would flow from *A* to *B*, on account of the high heat-resisting properties of asbestos or firebrick. Similarly, all matter offers a certain amount of resistance to the flow of electricity; that is, tends to prevent its flow. Most all good conductors of heat are good conductors of electricity. For example, copper is one of the best conductors of heat and also one of the best conductors of electricity. A very simple experiment can be made to test the heat-conducting properties of copper by taking equal lengths of copper and iron wire, using equal cross-sections in either case. No. 10 or No. 8 is a good size, and about 8 in. in length. Take one in each hand and hold each about the same distance in the flame of a bunsen burner or blowtorch and observe which one of the ends you are holding gets hot first. It will be found that the copper will get uncomfortably hot before the iron begins to get warm, showing that the heat is conducted up the copper much faster than up the iron. The same thing is found in electricity; if equal lengths of the same size of copper and iron wire are connected to the same source of electricity, as in Fig. 7, it will be found that about six times as much current will flow through the copper as through the iron, showing that copper is a much better electrical conductor than iron—it offers about 1/6 the resistance.

No Perfect Insulators of Electricity

On the other hand, firebrick, asbestos and other materials offer high resistance to the flow of heat. They also offer high resistance to the flow of electricity. Furthermore, there are no perfect insulators of heat, neither are there any perfect insulators of electricity. This latter quality will be given more consideration further on in the course.

The unit resistance offered by a substance to the flow of an electric current is called an ohm, after Dr. Georg Simon Ohm, a German physicist. The ohm is the equivalent of the resistance offered to the flow of an electric current by a column of mercury 106.3 c. (27 in.) long by 1 sq.mm. (0.00155 sq.in.) in cross-section at 32 deg. F. This is approximately equal to the resistance of a round copper wire 1000 ft. long by 0.1 in. diameter.

In Figs. 3 and 4 a flame was used to create a difference of temperature between the parts *A* and *B*. This difference of temperature could have been obtained by placing *A* in acid, although not to the same extent as by applying fire. Hence we have heat produced by acid attacking the metal, just as in the voltaic cell electric pressure was produced by the acid acting upon the zinc plate. Thus it is seen that a difference of heat pressure, or temperature, and a difference of electric pressure can be produced in the same way. Furthermore, an electric pressure can be produced by heat. When two dissimilar metals are joined together and the joint between them is heated, a difference of electric pressure will exist between them. Such a scheme is called a thermocouple and is illustrated in Fig. 6. When used in this way, antimony and bismuth produce the highest voltage. The electric pressure produced in this manner is very small, consequently the scheme has not come into very extensive use. Nevertheless, it shows the close relation between heat and electricity. In the introductory lesson it was pointed out that heat was produced by the friction of one body rubbing on another, and that a difference of electric pressure was produced by a conductor moving through a magnetic field cutting the lines of force.

Editorials

The Greatest Benefit to the Largest Number

The strength and development of a commercial or industrial organization depend very largely upon the vision of the future, as seen by those in responsible positions, and the efforts made to meet changed conditions. This is equally true of an association representing an industry. If it is to make progress and increase its field of usefulness to its members, the leaders must have the proper vision of the future.

The development of the electrical industry has been phenomenal. Never before in the history of nations has an industry made such rapid advancement. Consequently, an association that is to keep abreast of the ever increasing needs of such an industry and represent it, must ever broaden its scope. When we look back over the development of the American Institute of Electrical Engineers, we see that its growth has been just as phenomenal as that of the industry it represents. This could only have been brought about by an ever broadening policy to meet the needs of its members.

For many years the regular monthly meetings of the institute were held in New York City, and no doubt this was justifiable. But today there are in this country many industrial centers that rank in importance with this great metropolis. In these industrial centers not only are large numbers of electrical engineers and electrical workers employed, but there are many developments that are of interest to all men in the industry.

Last year, at the suggestion of President H. W. Buck, the practice of holding the regular monthly meetings in New York was abandoned for the broader policy of having these meetings at various centers of industrial activity throughout the country. The large attendance at the different regular monthly meetings outside of New York City has justified the statement of Mr. Buck at the Philadelphia meeting in October: "Holding meetings for the benefit of men in other cities who do not make a practice of attending the New York monthly meetings and the annual convention is highly desirable, and men who have not been heard before will take part in the discussions and thereby enrich our transactions correspondingly." Not only are these men reached at their centers of activity, but these meetings which have been brought to them will create an interest and encourage them to attend the meetings in other localities.

Another advantage in holding the monthly meetings in different places is that it is possible to have meetings at centers which are most closely connected with the subjects of the papers presented. Next to the large attendance at the Philadelphia meeting in October, the great outstanding feature was that those present were given the opportunity of seeing in operation the latest achievement in the subject under discussion—namely, the phase converter for taking single-phase power from a polyphase system.

If there is one thing that will result in the greatest benefit to the largest number of the institute members, it is holding the monthly meetings where the majority are interested in the papers presented.

The Midwinter Convention always affords the members an opportunity for visiting the power plants and substations in and about New York City. This feature has always offered considerable attraction, unfortunately the trips, this season, were cancelled at a rather late hour after being arranged for. This may have been justifiable but apparently it seems like taking unnecessary precautions. However, those who attended the convention Feb. 14 to 16 must feel well repaid and not only had their views of the industry broadened but also received many an inspiration. A report of this convention is to be found elsewhere in this issue.

The Horsepower of Our Battle Cruisers

Discussion has been rife in the daily press concerning the wisdom of installing electric drive in the new battle cruisers about to be laid down for the United States Navy. The arguments have divided between the advocates of electric drive and those of reduction gearing, and have for the most part dealt in generalities savoring of personal interests or prejudices. Without attempting to pass on any of the views advanced, it would nevertheless seem that the electric drive should present no greater difficulties than have been successfully handled in many of our large power plants. In fact the Navy Department might profitably seek the advice of some of our well-known central-station engineers both as to design and operation of these huge electric plants on shipboard.

Fundamentally more important than the type of drive is the questionable necessity for such enormous power as has been specified for these ships—a point that appears to have been overshadowed by the propulsion controversy and generally overlooked save by a few naval officers and the shipbuilders directly concerned. Not content with a substantial advance in design, but intent on surpassing by the widest margin anything afloat, the Navy Department, at the instance of Congress, has laid plans for these vessels of battleship caliber with a speed of thirty-five knots. The fastest battle cruisers in the British navy are said, upon excellent authority, to be capable of doing little better than twenty-nine knots, newspaper reports to the contrary notwithstanding. When it is recalled that the power required to drive a ship increases approximately as the cube of the speed, it will be realized at what an enormous expenditure in power this increase in speed is attained. It is estimated that to drive one of these ships at thirty-five knots will require one hundred eighty thousand horsepower, or three-quarters of that required to handle the combined subway and elevated load in New York City during the rush hours. Small wonder that some of the shipbuilders have acquired the proverbial cold feet when

asked to submit bids guaranteeing performance of these vessels at the prices stipulated.

Had we been content with, say, thirty knots for these ships, the required power would have been about one hundred and ten thousand horsepower—a substantial reduction. The ships would have still been a little faster than any others of their class; it would have simplified to some extent the question of propulsion; it would have presented a more tangible problem for the shipbuilders; and work might have now been progressing upon these badly needed units of the fleet; whereas valuable time is now being lost in profitless discussion and in trying to decide whether the shipbuilders can be induced to accept the risk at an increased price or whether the ships shall be built in the Government Yards.

Use for Reciprocating-Engine Works

The shortage of ships has long been keenly felt by America, as it has been by the Entente abroad. If we are to base judgment of the rate of destruction of ships by German submarines upon the performance of these undersea crafts since Feb. 1, the situation will soon be alarming indeed. In fact, this destruction is now progressing at the rate of about 16,000 tons per day.

America will need ships—many of them. Those who know, quite generally agree that ships of small tonnage, 5000 to 10,000, are most desirable. They may be standardized in construction, thus greatly lessening the cost of building over a nonstandardized plan, and after the conflict many of those that survive would be available for tramp service.

There are many reciprocating-engine works that, since the wide application of the steam turbine, have not been working to capacity. Most of these shops likely have all their equipment. Why would it not expedite shipbuilding if some of these plants, many of which are working much below capacity, were to be set to work building engines for the ships we are to need?

Rupture of Boiler Tubes

According to the *Locomotive*, there were one hundred boiler explosions during the months of August, September and October of last year. Thirty-four of these accidents were confined to the rupture of tubes of water-tube boilers. It was but a few years ago that boiler accidents were most frequent with the fire-tube type, such explosions usually being of a severe character and resulting in extensive property damage and almost invariably in the loss of life.

Rupturing of tubes in water-tube boilers is, as indicated in the foregoing, assuming a large proportion of the whole number of accidents. Naturally, the service is severe, especially on the bottom rows of tubes, which are exposed to the fiercest heat of the furnace. If scale is allowed to accumulate to any extent, the tendency of the tube to burn is increased, and a burnt tube is more easily ruptured than one that has not been injured.

The probabilities are that the number of tube failures will not decrease in the future. On the contrary, it is likely that it will increase, because of the growing use of water-tube boilers, the higher steam pressures carried.

Owing to the extensive use of stokers, a fireman stands a better chance of escaping without injury when a tube ruptures. With hand-fired boilers there is the danger of the steam, hot water and live coals being blown out through the furnace doors. If the fireman is in front of a boiler when this happens, he has but a small chance to escape without burns.

We have long advocated the use of furnace doors of a type that cannot be blown open, as a protection for the firemen against serious or fatal injury. Not a few boiler furnaces are so equipped, but on the majority the ordinary type of swing door is used. If the owner of a steam plant will take no steps to safeguard his firemen, the latter should use all caution possible while employed in the boiler room and not stand in front of the furnace doors when it is unnecessary to do so. It is an easy matter to get into the habit of standing out of the direct line of a fire-door, and such a practice may save a life.

Society of Refrigerating Engineers Regulations Committees

It was quite definitely shown at the last yearly meeting of the American Society of Refrigerating Engineers that immediate action should be taken to formulate regulations for the installation and operation of refrigeration-plant machinery. Not long prior to the meeting a serious explosion of a small automatic absorption plant at Brooklyn wrecked a building and occasioned loss of life, and an explosion of a welded receiver in Newark, New Jersey, killed a number of workmen. Those in attendance at the meeting seemed agreed that haste in formulating rules was imperative because a serious explosion might cause regrettable legislation in some cities and states to ride to enactment on a wave of popular clamor. This fear is not all timidity. If we remember correctly, it was the Brockton explosion that drove through the Massachusetts Statehouse a boiler law which many conscientious men were years amending to reasonableness. In these days of public support of safety-first campaigns a repetition of this is imminent.

We are pleased to know that at a recent meeting of the Council of the American Society of Refrigerating Engineers, the Committee on Municipal and State Regulations appointed ten subcommittees which are to work on the following subjects: Sample statute, introduction, definition of refrigerating machinery, safety devices, operation, installation, construction, fire regulations, autogenous welding; also there is a program committee. The personnel of these committees is, on the whole, admirable, and excellent work carried through with dispatch is expected.

Those supporting or contemplating support of refrigeration-safety legislation should find it of advantage to consult with these committees, who would, we believe, be glad to have impending legislation called to their attention. Other societies that have similar committees should get in touch with the American Society of Refrigerating Engineers that there may be consistent organization to expedite the end to which all must surely aim.

The licensed marine engineer is exempt from military service and cannot be drafted in case of war. The members of Marine Engineers Beneficial Association No. 33, New York City, set a patriotic example at their last meeting, by passing unanimously a resolution offering their services to the Government in any capacity.

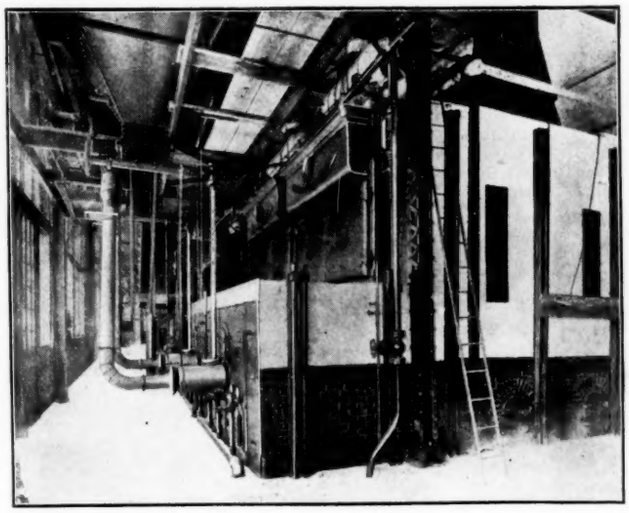
Correspondence

Pulverized Coal Under Boilers

The reference to powdered coal in the Jan. 2 issue, page 6, leads me to offer the following comments:

To obtain success in burning pulverized coal under boilers, we have found by experience that it is necessary to design the furnaces for the maximum rating at which the boilers are to operate. In other words, there is a fixed ratio between the cubic contents of the furnace and the amount of coal burned in a given length of time. It is necessary to have the furnace contents amply large so that the coal, when it is blown into the furnace, will have sufficient time to be thoroughly consumed before it comes in contact with the practically cold boiler. This makes a smokeless condition and practically eliminates any CO in the waste gases.

Directly in front of the boiler we install a pulverized-coal storage bin at the bottom of which is a screw feeder operated by a variable-speed motor. The coal is fed from



BOILER ROOM AT PARSONS PLANT

the bottom of the bin and is allowed to drop into an induction-type burner, whence it is blown into the furnace.

This gives complete control of the quantity of coal fed to the boiler, and the air supply. The induction burner is usually supplied with air at from 2 to 3 oz. pressure, and only about 50 per cent. of that required for combustion. By means of a cone-shaped valve on the burner, however, the additional 50 per cent., and any excess air desired is induced and blown into the furnace at a reduced pressure, from ½ to ¾ oz., practically fogging the coal in, so that it will burn like natural gas. With this arrangement the percentage of excess air can be reduced to a minimum.

There are a number of advantages in favor of using pulverized coal under boilers when the conditions governing such an installation are thoroughly understood. The coal is dried before it is pulverized, and practically no moisture is allowed to enter the furnace. With a properly proportioned furnace the life of the furnace refractories should be increased on account of more even distribution of the gases in the furnace. The control of the furnace operations is at the will of the operator with pulverized coal, and peak loads can be taken care of promptly. Pulverized coal, when burned in a properly proportioned furnace, is smokeless. The human equation in the operation is eliminated to a great extent.

Pulverized coal can be properly classed as a fluid fuel because it is of a gaseous nature and is mechanically fed in such manner that the rate of feed does not vary unless changed by hand. Perfect uniformity, therefore, in the rate of fuel fed is obtainable and at no additional personal attention. It has the advantages over other fluid fuels, however, of being ready to burn as it enters the furnace, as it is mixed at the burner, whereas other fluid fuels must be atomized and distributed after entering the furnace.

I do not hesitate to assert that 10 per cent. represents the difference between the average conditions in the average plant and those which are present during a boiler test; with pulverized coal there is no reason why there should be any difference in the furnace conditions.

With the pulverized-coal equipment installed in the power house of the Missouri, Kansas & Texas R.R. at Parsons, Kan., which equipment has been in operation since July, 1916, we are burning coals today carrying as high as 22 per cent. ash and as low as 25 per cent. volatile, and as high as 4.7 per cent. in sulphur with no detrimental results. Of course, the better the grade of coal burned the better operating conditions will result.

In making comparisons of stoker and pulverized-coal installations, I find that in plants of from 3000 to 4000 hp. and upward a first-class pulverized-coal equipment will not exceed in price that of a first-class stoker equipment, taking everything into consideration.

The ash from pulverized coal is more readily handled. There will be little fluxing condition in the furnace proper. In burning certain grades of bituminous coal in pulverized form and when the coal contains an ash with low melting point, a considerable quantity of ash accumulates on the bottom of the furnace and is readily removed.

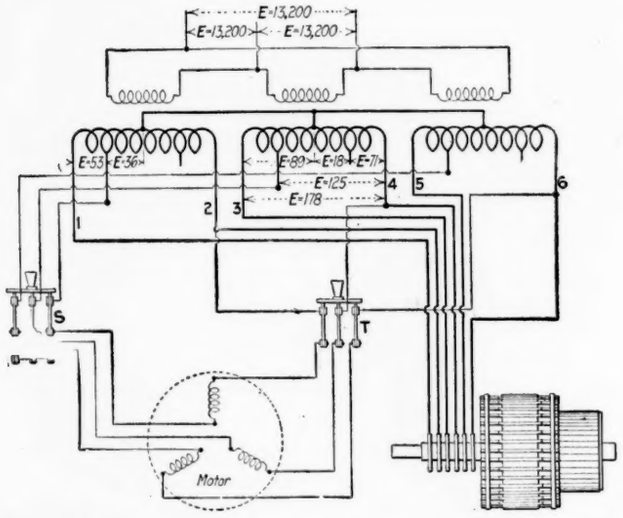
H. G. Barnhurst,
Chief Engineer, Fuller Engineering Co.
Allentown, Penn.

Oil-Burning Furnace

G. C. Long desires to correct an impression that appears to prevail that he attempted to discredit the Matteson oil burner in his discussion of the subject of oil-burning furnaces in the issue of Dec. 5, 1916, page 794. In the first paragraph in the second column it will be noted that plurals (models, designers and burners) are used and that the burner under discussion was that described Sept. 26, on page 464, and not the Matteson. Mr. Long says if there is any inference of the kind it is the editor's fault, anyway.

Connecting a Three-Phase Motor to a Six-Phase Circuit

In a plant where direct-current motors were used throughout, considerable trouble was experienced on one of the machines from metallic dust in the air causing sparking at the commutator and brushes and many objectionable shutdowns. The power was obtained from a 13,200-volt three-phase line which was reduced through



INDUCTION MOTOR AND ROTARY CONVERTER CONNECTIONS TO A THREE-PHASE TRANSFORMER

a three-phase transformer and converted into direct current by a six-phase diametrical-connected 250-volt rotary converter. A squirrel-cage induction motor would have been the ideal solution, but it was desired to avoid the transformer equipment if possible as the motor was of small size.

The possibility of utilizing the transformer supplying the rotary was considered, but the odd voltages obtainable for a three-phase connection did not allow a standard three-phase motor to be used. The three secondary coils of the transformers were connected at their neutral points, therefore, with the tap voltages as shown in the sketch. The nearest standard voltage possible for three-phase is $89 \times 1.73 = 154$ volts, and this would require a special machine, which could not be had in any reasonable time, consequently the prospects for an induction motor did not seem bright. The matter, however, was finally solved by using a standard three-phase "Y"-connected 220-volt motor. The ends of the coils which had been connected in "Y" were disconnected and led outside to terminals, so that the motor now had six terminals instead of three, as indicated in the diagram. Each phase of the motor was connected across a 125-volt section of a transformer-secondary coil; this left the motor operating at practically normal voltage, since, originally, it operated at 220 volts across the "Y" terminals or $220 \div 1.73 = 127$ volts on each phase winding.

The motor required six wires, as shown, but was nevertheless a three-phase motor, as it contained only three groups of coils as before, and at full load it would use the same amount of current in each winding as a three-phase machine.

The motor was started without a compensator by connecting the windings in "Y" by throwing the double-throw switch S to the down position, while the other ends of the coils were connected to a three-phase voltage of 154 volts by the single-throw switch T, which gave good starting results. EUSTIS H. THOMPSON.

Baltimore, Md.

Boiler Dry Pipe Lengthened

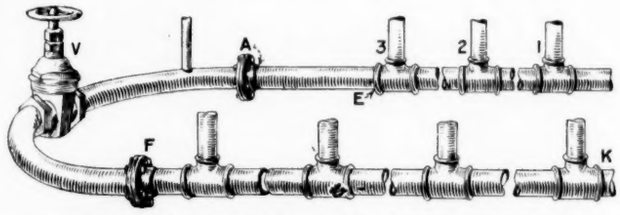
A bank of oil-fired Stirling boilers, rated 700 hp. but often forced to 80 per cent. overload, gave serious trouble by water being carried over with the steam and on one occasion doing considerable damage.

The steam was taken from a 6-in. dry pipe about 3 ft. long. This was extended to about 5 ft. with the same area of holes per foot drilled in the extension pieces as were in the original, and the same caps were used. This was done about four years ago, and no serious trouble has been experienced since. W. CANDLISH.

Redondo, Calif.

Corrosive Action in Feed Line

The main boiler-feed line at our plant—about 50 ft. long of 3-in. extra-heavy pipe—was attacked by a corrosive action of some kind. It was thought best to cut away the section between A and E (see illustration) and replace it with a length of good pipe. Just why this section failed, while the remainder of the line seemed to be in good condition and no leaks had occurred, was a puzzling question; and why did corrosion take place on the upper surface of the pipe, the holes or pits appearing almost exactly in line with one another? The thread at A was partly eaten away, while at E the thread was good. One of the suggestions as to the cause of the corrosion was that since the boilers fed from the connections, 1 and 2 were in operation more regularly than that fed from No. 3, it followed that there was little circulation in the section of the line lying between 3 and the dividing valve



ONE SECTION OF LINE FAILED FROM CORROSION

V, and thus the "dead" water produced gases which rose to the upper surface of the water and attacked the metal. In opposition to this it will be seen that the feed main is a loop, and since the portion of the main lying between F and K was seldom used, this section would be more subjected to such action, but no leak had developed in this line.

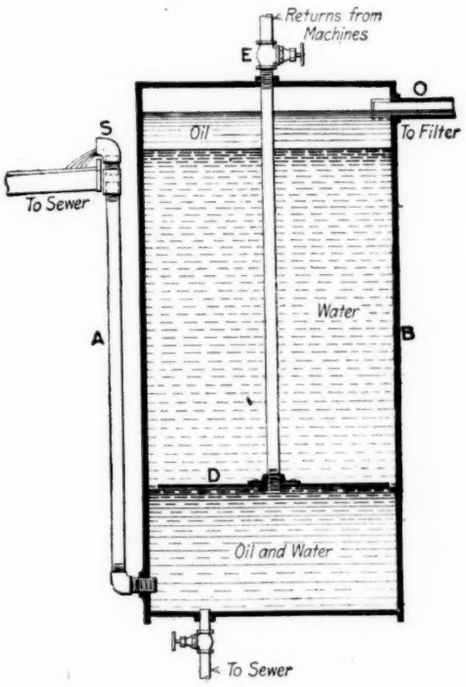
Another suggestion was that the pipe was made of inferior and light material, but when the corroded section was taken down it was found to be extra-heavy pipe of good quality. The next suggestion was that the area of the main line was too large and by reducing it the corrosive action would cease because the entire surface of the pipe would be continually swept by the current of water and thus the surface would be kept clean and corrosive action would be eliminated. This "listened good," but it was impracticable to make the changes, so a ¾-in. pipe

with a valve was connected from the upper side of the bend to the suction line of the feed pump, and by manipulating the valve, a circulation in the "dead end" of the main and a constant piston speed of feed pump is maintained. Since this change was made, there has been no trouble with the line. WILLIAM KAVANAGH.

New York City.

First Unit of Oil-Filtering System

Dust from the street and coal bins blows in through doors and windows and finds its way to the oil drip pans and thence to the oil filter. This necessitated frequent cleaning and repacking of the filter, and even this did not



PRIMARY OR WATER SEPARATING FILTER

give us really clean oil, therefore it became necessary to employ some means to eliminate the greater part of it before it reached the filter.

The device shown in the illustration has solved the problem. It is made on the principle of the U-tube, one side of which is filled with water and balanced by a column of oil and water in the other side. *A* constitutes the water column, which is balanced by the column of oil and water in *B*, and *S* is the overflow on a long thread and is used to vary the height of the water column and consequently the amount of oil in *B*. By having *S* from ¼ to ½ in. lower than the point of overflow *O*, a balance is obtained and the amount of oil in *B* necessary to produce the balance can be readily calculated from the difference in the specific gravity of oil and water. A mixture of oil containing dirt, grit and drip water from the machines is returned to this auxiliary separator through pipe *E* extending almost to the bottom of the tank *B*. Disk *D* serves to retard the tendency of the oil to rise, allowing more time for the separation, and the oil has to travel along the under side of the disk to the edge before it can rise to the top.

The oil level in *B* will always be higher than the overflow *S*, therefore the water in *B* cannot rise high enough to overflow to the filter. This is a great advantage, because formerly the drip water caused the water level in the filter to rise, and sometimes it reached the suction of the oil pump, resulting in hot bearings.

Points to be observed in the construction of this separator are: The diameter of tank *B* must be large enough to prevent the oil level from rising too rapidly, otherwise the balance will be destroyed and the oil will drive the water out through *A*. For the same reason the overflow opening *O* must be of liberal size. We have found the weir or rectangular-shaped outlet, about 3 in. wide, the best for this purpose.

To put this primary filter into operation first fill tank *B* until the water overflows at *S*, then introduce the returns through *E*. As the oil level continues to rise, water will overflow from *S* until oil begins to overflow at *O*. Subsequently, any water or oil reaching tank *B* will cause an overflow at *S* or *O*.

Our tank is 18 in. diameter by 3 ft. high, and it takes care of the oil from three reciprocating engines totaling 2000 hp. JOSEPH JACOBS.

Paducah, Ky.

Useful Hints on Babbitting Bearings

The first requisite to successful babbitting is clean melting pots and ladles, and to secure this, they should be heated nearly red-hot and sprinkled with powdered rosin. This will give off a dense white smoke that can be ignited, and when it burns out the ladle or pot can be brushed off with a cloth and it will be absolutely clean.

Bearing metal should not be overheated, for a part of the mixture will be burned, forming a dross that must be removed by skimming, before the metal is poured. The molten metal should be well stirred by dipping the ladle to the bottom of the pot, bringing it up full and raising it a couple of inches above the surface of the metal in the pot and pouring it back repeatedly until the metal becomes properly mixed.

The entire bearing should be poured at one time because two pourings seldom join well. Also a small gate on a long bearing is likely to result in a chilled or defective bearing. There is no good reason for making gates very small, although this appears to be practice with some. The right pouring temperature for a bearing metal that does not contain a large percentage of copper can be found by the use of a dry pine stick. Be sure it is dry, otherwise the metal will fly. Insert the stick into the melted metal, and if the heat is right, the stick will become charred to a fairly dark-brown color; if it chars black or burns, the metal is too hot. Whenever possible, it is good policy to heat the iron casing and the mandrel or shaft before pouring the metal. Here again care must be used not to overheat.

To avoid chilling the metal, the melting pot should be brought as near the job as possible. Clay is one of the best materials to use to hold (dam) the molten metal in the mold, but a mixture of asbestos, putty and oil will give excellent results in small work as it will not harden like clay. For straight-end work a rope of hemp well rubbed over with thick wet clay or the asbestos and putty mixture will give good service. The clay must be softened up after each run, but with the asbestos mixture as many as 15 bearings have been run without the addition of any more oil. Care should be taken

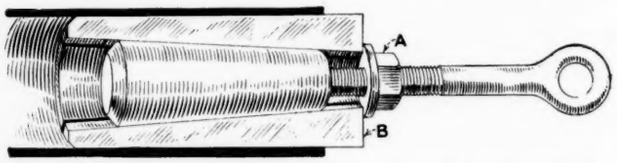
to provide vents to allow the escape of air and gas from the bearing while pouring. If the metal is run into a cold shell, it is liable to be loose when cooled and to require peening in with a round-end hammer.

There are a number of different bearing metals, but the foregoing tips will apply to them all.

Portsmouth, Ont., Canada. JAMES E. NOBLE.

Convenient Tube-Pulling Device

The illustration shows a handy tube puller that I have used with success. It can be easily made with a lathe and shaper. The body is turned to fit the inside diameter of the tube and bored out tapering for a mandrel and then split in three sections on the shaper. A tapered mandrel is fitted and joined with a long eye-bolt, nut and washer, as shown, and tightening nut *A* wedges the



SELF-TIGHTENING MANDREL FOR PULLING TUBES

device in the tube. A strong pull with a block or chain falls hooked into the eye will draw a tube out even if badly blistered. Turning the tube with a pair of pipe tongs when it is far enough out to use them helps a lot. H. C. WILLIAMS.

Concord, N. H.

Air Chamber on Gage Line

The hand on a pressure gage connected to a pump discharge pipe often vibrates with each stroke of the pump, making reading difficult and causing blots on recording-gage charts. A 3-in. pipe, about 1 ft. long for 50 lb. pressure up to 3 ft. for 150 lb. or greater, fitted with reducers at each end and near the bottom with a bicycle air valve soldered in, placed in the gage line will greatly reduce the fluctuation. If the air cushion is insufficient with the air naturally entrapped in the chamber, more air may be pumped in with a small hand bicycle pump till the desired effect is obtained. J. S. MARCUS.

Boulder, Colo.

How Do Some Engineers Hold Their Jobs?

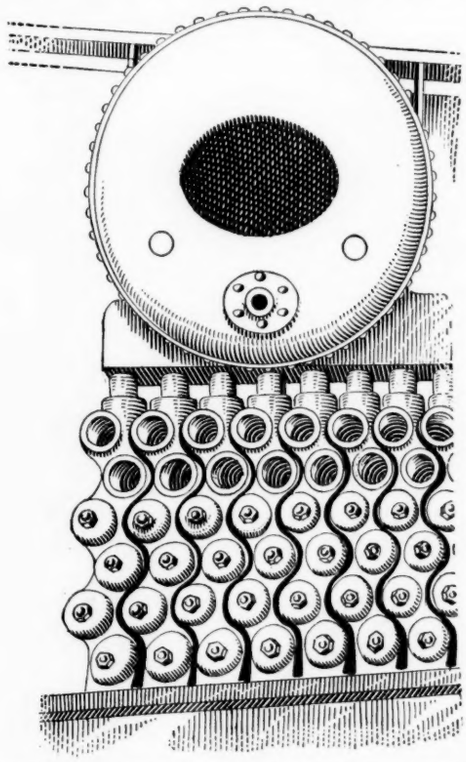
In reference to the comment on the Foreword of Nov. 14, 1916, by B. Meyer in the issue of Jan. 16, perhaps he has not had experiences similar to some I have had in the last two years.

I am chief operator in a small (1600-kw.) hydro-electric plant and have had twelve years' experience with steam and water-power plants. My latest attempt to break into a better position was when the manager of a large paper mill sent for me to come and look over his steam plant, giving me to understand that I was to take charge if I could handle it. I spent the greater part of a day with him in looking it over and found things in bad condition. As we walked back of the first paper machine, I counted 27 bad steam leaks, and steam was blowing right through a trap to the atmosphere, and the engines (high-speed) were pounding badly. In the main engine room the direct-current generator brushes were sparking, and the lubricator on one engine was empty. In one of the boiler rooms one 600-hp. boiler (stoker-fired) had the stoker speeded up to the limit, the six other boilers were simply loafing. We did not succeed in finding the chief, but the manager informed me he was getting $150 per month and asked me if I could make any improvement. I told him that in a week I would guarantee him a saving of six tons of coal per day (24 hours), and he said he would let me know in a week. After two months I received a letter from him offering me $20 per week as foreman of the piping gang. The same chief engineer is there yet, and there is no improvement in the operation of the plant. Can anyone explain how a man wasting a firm's money in such a way holds his position? V. C. WOOD.

Copenhagen, N. Y.

Removing Scale from Between Headers

After an inspection of the B. & W. boilers, the superintendent ordered the scale or incrustation in between the header sides removed, but offered no suggestion as to how the work should be done. The asbestos rope packing



INCRUSTATION ACCUMULATED BETWEEN HEADERS

was removed from the outer edges, and air tools were tried, but the width of the spaces varied, and special chisels had to be made to suit them. The chisels would jam, and a great deal of time was lost in freeing them, since the force of the air hammers was too great. One-pound hand hammers were too slow, and the work was given up. I should like to have the opinions and experience of others on this matter. H. C. WILLIAMS.

Concord, N. H.

Inquiries of General Interest

Increasing Thickness of Flywheel Rim—How would the safety of a flywheel be affected by increasing the radial thickness of the rim from 2 in. to 3 in.? F. M.

Increasing the thickness of the rim would increase the weight and the centrifugal force in direct proportion to the increase of thickness. Therefore no benefit could be derived from additional tensile strength obtained in direct proportion to the thickness. Assuming that the arms of the flywheel and their connections with the rim would be strong enough, the only advantage of increasing the rim thickness would be to improve the transverse strength of the rim, acting like a continuous beam from arm to arm, in resistance to the centrifugal effect.

Pressure Side for Disk of Globe Stop Valve—Should a globe stop valve be set in a steam line so the pressure will be above or below the disk? D. D.

A valve should be so set that, when it is closed, the pressure will be on the under side of the disk. This arrangement not only permits of packing the spindle of the valve when closed, but causes the disk to be pressed toward the spindle. Serious accidents have resulted from breaking of valve spindles by their being pulled away from the disks with pressure holding the disks to their seats, or it has been impossible to open the valves. The only advantage in having the pressure above the disk is that, when the valve is closed, the pressure assists in holding the valve to its seat.

Radius of Curvature of Link Slot—In a reversing valve-gear with a Stephenson link, what is the purpose of curving the link slot and what is the radius of the curvature? C. F. M.

The object of curving the link slot is to equalize the lead of the valve for all travels, and the radius of curvature of the slot should be such as will make the increase or decrease of the lead the same for both strokes of the piston. The best radius of curvature is usually obtained in practice by the use of models and trial drawings. It is approximately a little less than the length of the eccentric rod, or about equal to the distance from the center of the eccentric to the center of the link-block less twice the sum of the lap and the lead.

Sticking of Valve Bonnets—What causes valve bonnets to stick fast and require so much more force for their removal for the first examination or regrinding of valves than the bonnets of valves that have once been removed? F. W. B.

When the bonnets of new valves are screwed into place with fresh and clean metallic surfaces, the materials of the bonnets and bodies become ground together and there is an interlocking of the irregularities of the surfaces that usually increases with the length of time the surfaces are left undisturbed. Before being placed in service, the bonnets of new valves should be removed and their screw threads and bearing flanges should be given a light coating of plumbago and the bonnets should be replaced with only sufficient force to secure tight joints.

Saving from Increased Temperature of Feed Water—When steam is generated at a boiler pressure of 150 lb. from feed water at 60 deg. F., what percentage of saving would result from increasing the temperature of the feed water to 130 deg. F.? G. G. W.

As found from the steam tables, each pound of steam at 150 lb. boiler pressure, or 165 absolute, contains 1195 B.t.u. above 32 deg. F. Hence for conversion of a pound of feed water at 60 deg. F. into steam at 150 lb. boiler pressure requires 1195 — (60 — 32) = 1167 B.t.u. With the temperature of the feed water 130 deg. F., each pound of feed water for generation into steam would require 130 — 60 = 70 B.t.u. less than formerly and the saving would be (70 × 100) ÷ 1167, or about 6 per cent.

Oil in Exhaust-Steam Heating System—What effect has the oil contained in exhaust steam on the operation of pipe coils? Should an oil separator be used? How can pipe coils be cleaned of accumulations of oil? E. M. C.

An oil separator should be used for removing all oil possible from the exhaust at the point where it is supplied to the heating system. The main objections to carrying over oil are that condensation of lighter ingredients causes leaks at joints and disintegrates most kinds of packings, and deposits of heavier compounds clog the openings of pipes, valves and fittings, and oil remaining suspended in the return water renders it unfit for use as boiler-feed water. An exhaust-steam heating system can be cleared of oil by filling it with a concentrated solution of soda ash that has been diluted with about an equal quantity of water. When the system has been allowed to stand filled with the soda solution for about 5 hours, one radiator at a time should be flushed with clean warm water pumped through the system at a high velocity.

Berggren's Equation for Flow of Steam in Pipes—In Berggren's equation,

$$W = 67\tfrac{1}{2}\sqrt{YP}\left(\frac{D^5}{L(D+36)}\right)^{\frac{1}{2}}$$

for the flow of steam in pipes, quoted p. 375, Mar. 14, 1914, issue of "Power," what do the letters represent? J. M.

In this formula,

W = Weight of steam delivered, pounds per minute;
Y = Density or weight in pounds per cubic foot of dry saturated steam at the mean pressure of the steam in the pipe, as obtained from steam tables;
P = The drop in pressure, or difference in pressure of the steam at the entrance end and the discharge end of the pipe, in pounds per square inch;
D = Diameter of pipe in inches;
L = Length of pipe in feet.

Third Pass for Horizontal Return-Tubular Boilers—What are the advantages and disadvantages of passing the gases of a return-tubular boiler over the top of the shell instead of conducting them directly from the front end of the flues to the chimney? M. M.

Provision of a third pass for the gases along the top of a return-tubular boiler shell is a form of boiler setting that has almost entirely disappeared from good practice. The construction of such a flue, or pass, complicates the setting and failure of the seal between the top pass and the furnace has resulted in burning the sides of the boiler from passage of the hottest gases over portions of the shell above the water line. In operation the boiler quickly becomes covered to a considerable depth with soot, which is about five times as efficient a nonconductor of heat as fine asbestos. It is generally conceded that no practical advantage is to be gained by providing a pass for the gases along the top of a boiler, and it has been demonstrated that under ordinary conditions such a third pass is decidedly detrimental to operating economy.

Equivalent Evaporation from and at 212 Deg. F.—If a boiler evaporates 9.84 lb. of water per pound of coal into steam at 115 lb. gage pressure, and quality 94 per cent., from feed water at an average temperature of 113 deg. F., what would be the factor of evaporation and equivalent evaporation per pound of coal from and at 212 deg. F.? J. R.

Each pound of the feed water would have to be heated to the boiling point, but only 0.94 of a pound would receive the latent heat of evaporation. By referring to the steam tables it will be seen that the latent heat of steam at 115 gage, or 130 lb. absolute, is 872.3 B.t.u. and the heat in the water is 318.6 B.t.u. Therefore each pound of the steam would contain (872.3 × 0.94) + 318.6 = 1138.56 B.t.u. above 32 deg. F., and when evaporated from feed water at a temperature of 113 deg. F., as each pound of the feed water would contain 113 — 32 = 81 B.t.u. above 32 deg. F., the heat added per pound of feed water would be 1138.56 — 81 = 1057.56 B.t.u. Evaporation of a pound of water from and at 212 deg. F. would require the latent heat of evaporation, or 970.4 B.t.u. per pound, so that the relative heat received per pound of feed water evaporated into steam under the actual conditions would be as 1057.56 to 970.4 and the factor of evaporation would be 1057.56 ÷ 970.4 = 1.0898. Evaporation of 9.84 lb. of water per pound of coal, under the conditions stated, would be equivalent to 9.84 × 1.0898 = 10.72 lb. of water evaporated from and at 212 deg. F.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Automatic Boiler Feed-Water Regulators

By F. W. Marquis, M. E.*

SYNOPSIS—The principles on which the various types or classes of boiler feed regulators are based are set forth and all makes on the market are classified accordingly. The right one to use in a given case is determined by the kind of service desired.

To have the operation of a steam boiler satisfactory and safe, it is necessary that the water level be maintained within certain limits. To accomplish this by means of some reliable mechanical device, instead of relying upon the constant attention of a fireman or water-tender, who is human and therefore liable to make mistakes, the advantage is apparent from the point of view both of safety and of economy of labor. As a result a number of devices called automatic boiler feed-water regulators have been developed, whose object is to control automatically the flow of feed water into a boiler so that the water level will be maintained within certain predetermined limits, and they seem to have a very high degree of reliability. Many advantages are claimed for them besides those mentioned, chief among which is increased boiler efficiency.

If, in connection with the automatic feed-water regulator, a high- and low-water alarm is installed, the danger of high or low water is reduced to a minimum, for in case the automatic regulator fails to operate properly, the fireman's attention is called to that fact by the alarm, and he can then control the feed by hand until the trouble with the regulator has been overcome.

Every feed-water regulator comprises at least two main parts, which may be termed the primary regulating device and the regulating valve. Since the boiler-water level is the thing that is being controlled, movements in this water level must be depended upon to operate the regulator or some part of it. The part of the regulator that is directly acted upon by changes in water level is what is here termed the primary regulating device, and this device must in some way control the feed valve so that the proper amount of water is fed to maintain the water within the required limits. The classification here given is based upon the primary regulating device. When so classified, regulators fall naturally into four classes or divisions.

CLASSES ILLUSTRATED BY ONE OF EACH TYPE

A good example of Class 1 (the float type) is made by the Elliott Co., Pittsburgh, Penn. As reference to Fig. 1 will show, it consists of a water column containing a float which controls a pilot valve whose function is to admit or exhaust steam from the diaphragm chamber of a "diaphragm controlling valve." The pilot valve is double; that is, it consists of two valves, the lower one of which controls the steam opening into the pilot-valve chamber and the upper one the exhaust opening from it. These two valves are attached to a common yoke and operate as one; when one is open the other is closed, and vice versa. When the water level is above normal the float rises, closing the exhaust valve and opening the steam valve, so that steam pressure is admitted to the pilot-valve chamber. This pressure is transmitted to the controlling valve and, acting on the diaphragm, closes it, completely shutting off the supply of water to the boiler. As the water level falls, the float descends, closing the steam valve and opening the exhaust valve, thus discharging the steam in the pilot-valve chamber, relieving the pressure on the diaphragm. The spring shown below the diaphragm then opens the feed valve, admitting water to the boiler.

For installations where the rate of evaporation does not fall below a certain amount, a "constant-flow controlling valve" is recommended. This differs from the valve shown in Fig. 1 only in the addition of a threaded bushing on the stem, which acts as an adjustable stop and prevents the valve from closing completely. The result is the same as would be obtained by means of a bypass around the automatically controlled feed valve; that is, it makes it impossible for the regulator to decrease the flow of feed water below a certain minimum.

Feed-water regulators belonging to this class and operating on substantially the same principle as that described are manufactured also by the Murray Specialty Co., of Detroit, Mich.; the American Steam Gauge and Valve Manufacturing Co., of Boston, Mass., and the Williams Gauge Co., of Pittsburgh, Penn.

There is, however, one regulator of the float type which operates on a principle rather different from that described. It is the "Watch Dog" regulator, made by the L. J. Wing Manufacturing Co., of New York. The feed valve of this regulator, as reference to Fig. 2 will show, is controlled by a piston which has feed-water pressure acting on its upper side, tending to close the valve, and boiler pressure on its lower side tending to open it. In the line conveying feed water to the upper side of the piston is a "reducer" through which there is a rather small opening, thus throttling the flow of feed water. The float-controlled pilot valve when open, allows water to flow from the chamber above the piston into the boiler through the float chamber. This causes the pressure acting on the upper side of the piston to decrease an amount depending upon the opening of the pilot valve (since the opening through the "reducer" is fixed) thus unbalancing the pressures acting on the two sides of the piston and causing the feed valve to open. Feed water will then enter the boiler, and the water level will gradually rise until the pilot valve is closed, when full feed-water pressure will act in the chamber on top of the piston. Since this is greater than boiler pressure, which is always acting on the lower side of the piston, the feed valve will then be caused to close. Thus the water level below a certain point will cause the feed valve to open, and above a certain point will cause this valve to close.

THE COUNTERBALANCED WEIGHT TYPE

The "Vigilant" feed-water regulator, made by the Chaplin-Fulton Manufacturing Co., of Pittsburgh, Penn., is described as a representative of the counterbalanced-weight type, Class 2, and is shown in section in Fig. 3. It consists of a regulator chamber containing a counterbalanced weight whose function is to control a pilot valve which admits and exhausts steam from the cylinder of a piston-controlled feed valve. The regulator chamber is located entirely above the boiler-water level, its lower end being connected to the bottom connection of the water column or some other point below the water level, and its upper end to the water column at the level of the middle gage-cock. It is evident that this chamber will be full of steam whenever the water level is below the middle gage-cock and full of water when the level is above that point. The weight in the regulator chamber is suspended from the end of a lever whose fulcrum is a small shaft, one end of which extends through a stuffing-box. Another lever which carries an adjustable counterweight is keyed to the end of this shaft. This counterweight is so adjusted that it will lift the weight in the regulator chamber when that chamber is full of water—that is, when aided by the buoyant effect of water—but will be lifted when the regulator chamber is full of steam.

The pilot-valve body is carried on the regulator chamber and is supplied with steam, as shown in Fig. 3. This valve has an upper and a lower seat and is so arranged that when against its lower seat it allows steam to enter and act on the piston of the controlling or feed valve, closing it; and when against its upper seat it closes the steam valve and opens an exhaust valve, thus allowing the pressure to escape and the valve to be opened by the spring.

CYCLE OF OPERATION OF PARTS

The operation is as follows: When the water level is below the middle gage, the regulator chamber will be full of steam, and the weight in that chamber will be at the bottom of the chamber. The pilot valve will then be against its upper seat, and the steam opening will be closed and the exhaust open and the feed valve will then be held wide open by the spring. When the water level in rising passes the middle gage, both openings leading to the regulator chamber will be under water, and the chamber will fill with water as the steam in it condenses. The weight will then be lifted by the counterweight and buoyancy of the water surrounding it, and the pilot valve will drop to its lower seat, closing the exhaust valve and opening the steam valve, admitting steam pressure to the piston of the feed valve and closing that valve, thus shutting off the supply of feed water. When so desired, a feed valve with a bypass, as shown in Fig. 4, can be used and this valve can be adjusted by means of the handwheel at the bottom, so that, as the maker says, "water may flow into the boiler constantly and almost as rapidly as it is evaporated, thus providing a more uniform feed."

*Abstract of paper before the Ohio Society of Mechanical, Electrical and Steam Engineers.

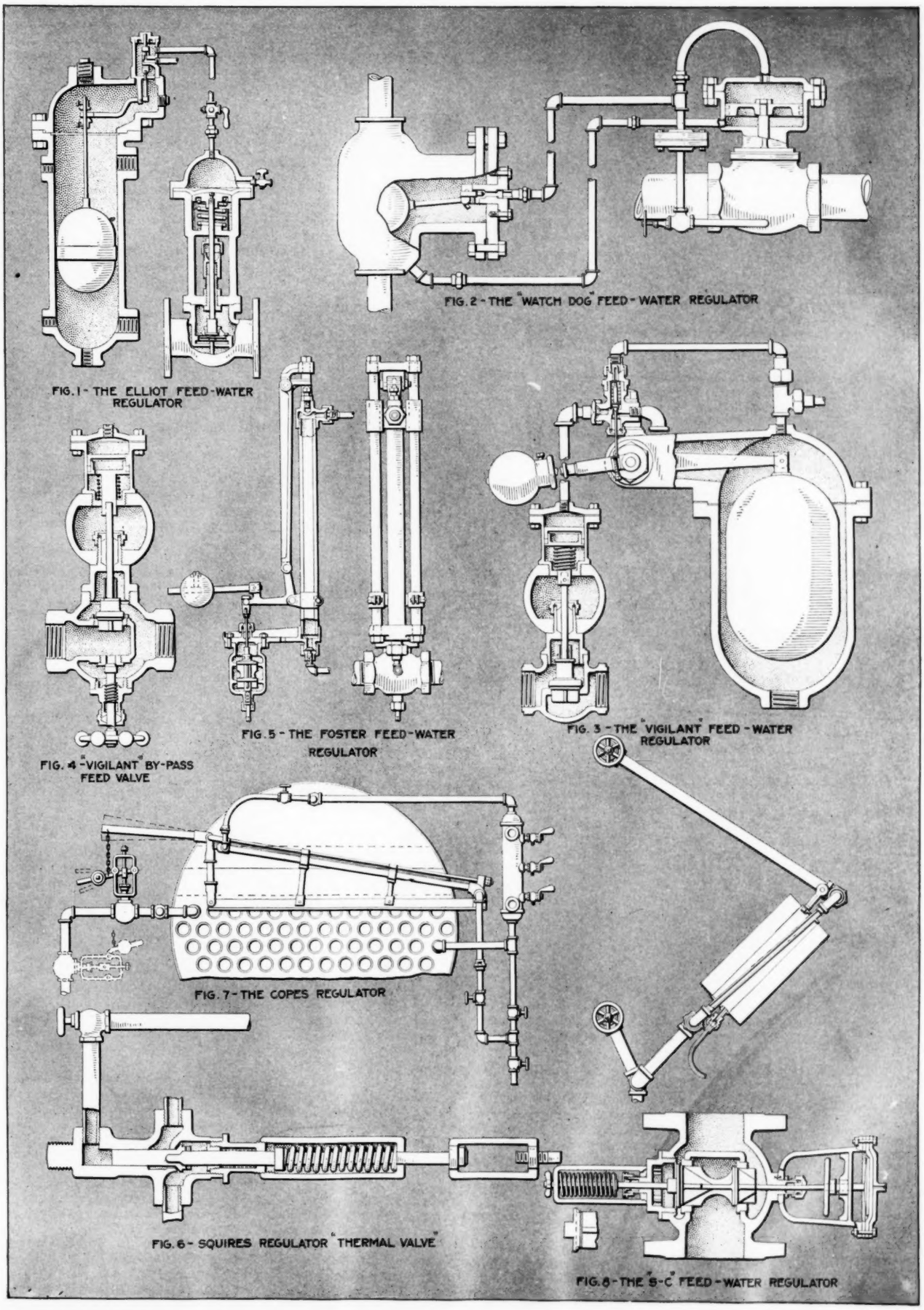


FIG. 1 - THE ELLIOT FEED-WATER REGULATOR
FIG. 2 - THE "WATCH DOG" FEED-WATER REGULATOR
FIG. 3 - THE "VIGILANT" FEED-WATER REGULATOR
FIG. 4 - "VIGILANT" BY-PASS FEED VALVE
FIG. 5 - THE FOSTER FEED-WATER REGULATOR
FIG. 6 - SQUIRES REGULATOR "THERMAL VALVE"
FIG. 7 - THE COPES REGULATOR
FIG. 8 - THE "S-C" FEED-WATER REGULATOR

REPRESENTATIVES OF THE FOUR TYPES OR CLASSES OF FEED-WATER REGULATORS

The Kitts feed-water regulator, made by the Kitts Manufacturing Co., of Oswego, N. Y., belongs to the same class as the "Vigilant." While differing considerably in detail construction, they operate on substantially the same principle. In the Kitts, however, the regulator chamber instead of being entirely above the water level, is on the same level as the water column, the boiler-water level being at about the center of the regulator chamber. The regulator chamber never fills entirely with either water or steam, but the water level is always the same in it as in the boiler, and the counter-balanced weight rises and falls with the water level and controls a pilot valve as in the case of a float-type regulator.

The Foster regulator, made by the Foster Engineering Co., of Newark, N. J., is an example of Class 3, group a, the fixed-level expansion-tube type. In this regulator the expansion tube, Fig. 5, is vertical and is located entirely above the boiler-water level. A connection is made at its bottom end to the lower end of the water column and at its upper end to that point in the water column at which it is desired to carry the water level. As already explained, this expansion tube will be full of steam and expanded when the water level is below the point of connection to the water column, and full of water and contracted when the level is above this point. As reference to Fig. 5 shows, the expansion tube when expanded, as it will be when the water level is slightly below normal, forces the adjusting screw against the short arm of the bell crank, which lifts and opens the feed valve, thus allowing feed water to enter the boiler. As the water level rises slightly above normal, the expansion tube will fill with water and as it cools off will gradually contract, moving the adjusting screw down slightly and allowing the weight on the bell crank to move down and close the feed valve, thus completely cutting off the supply of feed water.

It is evident that with this type of regulator, as with the float and counterbalanced-weight types, a very small change of water level will cause the feed valve to move from wide-open to tight-shut or vice versa, thus giving intermittent feeding.

THIS PRINCIPLE IS EMPLOYED BY MANY MAKERS

Regulators belonging to this class are also made by the H. E. Cade Co., of Philadelphia, and the C. E. Squires Co., of Cleveland, Ohio. The Cade regulator, although differing in construction, operates on substantially the same principle as that described, but the Squires regulator operates differently. In it the expansion tube is inclined so that its center is on a level with the desired water level. Its upper end is connected with the steam space of the boiler and its lower end below the water level. The level of the water in this tube will then always be the same as the water level in the boiler, and the ratio of the hot part of the tube to the cold part will change as the water level changes; that is, the length of the tube will change slightly as the water level changes, being greater for a low than for a high level. This expansion tube controls a pilot valve shown in Fig. 6, called a "thermal" valve. Steam is supplied to this thermal valve as shown at the left side of the figure, and as it enters the valve it comes in contact with what is called a "resistance plug," slightly smaller in diameter than the chamber which contains it, thus allowing a small amount of steam to pass it. If the thermal valve is in its closed position, as shown in the figure, corresponding to a contracted expansion tube and a high water level, the steam which leaks past the resistance plug will pass out of the valve through the pipe to the feed valve and will act upon the diaphragm of the feed valve, shutting off the supply of feed water. As the water level becomes lower, the expansion tube will expand and will open the thermal valve by moving the resistance plug slightly and allowing the steam to exhaust through the opening at the bottom of the thermal valve as long as the thermal valve is open; the feed valve will then close, thus shutting off the supply of feed water. In practice both the feed valve and the thermal valve remain partly open, and as a consequence there is a steady, continuous feed.

The Copes regulator, made by the Erie Pump and Equipment Co., of Erie, Penn., is an example of Class 3, group b, the variable-level expansion-tube type, and Fig. 7 will assist in understanding its operation. Its expansion tube is located and connected in a manner similar to that of the Squires regulator; that is, it is inclined and placed so that its center is on a level with the desired average water level; its upper end is connected to the steam space of the boiler and its lower end to the water space, and, as explained, as the water level rises, less of this expansion tube will be at steam temperature and more at a lower temperature. However, here the resemblance ceases, for in the Copes regulator no pilot valve of any kind is used, but the end of the expansion tube is connected directly to the short arm of a bell crank, which moves the feed valve by means of a chain and weighted lever connected to the valve stem; and as is evident, the opening of the valve varies as the water level changes and under a light load the feed valve would be nearly closed and the water level high. If the load were to increase suddenly, the water level would first rise slightly, but would soon begin to go down, and this would cause the feed valve to open gradually. The water level would continue to go down and the feed valve to open until the opening of the valve was sufficient to supply water and a condition of equilibrium would be reached and remained fixed until another change of load occurred. The feed would thus be continuous, following changes of load but lagging behind these changes.

Another regulator of this type, differing in details of design and construction but not in principle, is made by the McDonough Automatic Regulator Co., of Detroit, Mich.

The only representative of Class 4, the variable vapor-pressure type, is the "S-C" regulator, made by the "S-C" Regulator Co., of Fostoria, Ohio. In this regulator the part called the "generator" (shown in Fig. 8 above the valve) is inclined and placed so that its center is on a level with the desired normal, or average, water level. This generator is about half full of water and is connected by the small tube to the diaphragm chamber of the feed valve. The pipe through this generator is connected at its upper end to the steam space and at its lower end to the water space of the boiler as shown, so that the water level will always be the same in it as it is in the boiler and is continually giving up heat to the water in the generator, causing this water to boil, producing pressure in the generator. As the water level becomes lower in the boiler and a larger part of the generator tube is filled with steam, the heat is given up to the water surrounding it and the resulting pressure in the generator will increase. This pressure acts on the feed-valve diaphragm, tending to open the feed valve against the force of a spring. For each different water level there will be a corresponding pressure in the generator, and this pressure will be higher for low than for high levels. There will therefore be a certain definite valve opening corresponding to each water level. The same kind of feeding will consequently be obtained with this regulator as has been described in connection with the Copes regulator.

A. I. E. E. Midwinter Convention

During the three days, Feb. 14, 15 and 16, the American Institute of Electrical Engineers held its fifth midwinter convention in the Engineering Societies Building, New York City. A total of 583 members and guests were in attendance. The convention opened at 10:30 Wednesday morning with President H. W. Buck in the chair. He made the opening address, in which he pointed out the importance of the relation of science to engineering and the necessity of coöperation between science and industry.

Dr. C. R. Mann outlined the work accomplished by the Joint Committee on Engineering Education, representing the Engineering Societies, which was formed about three years ago, to investigate and, if possible, suggest ways and means of improving engineering education in our universities and colleges. He stated that the report of this committee was nearing completion, therefore what he had to say was preparatory to the presentation of this report to the members.

A paper was presented under the auspices of the Standards Committee on "Internal Temperatures of Alternating-Current Generators," by Ralph Kelly. Mr. Kelly not being present, the paper was abstracted by Prof. Alexander Gray, who by blackboard diagrams very clearly outlined the subject. The paper dealt with the internal temperatures of a number of alternating-current generators, this temperature being measured by thermo-couples placed between the armature coils in the same slot and in the center of the core. The differences between these measured internal temperatures and the corresponding surface temperatures, in the tests given, vary from 0 to 35.5 deg. C. This divergence is explained by the aid of the tests and of calculation.

At the afternoon session, Vice-President C. A. Adams called the meeting to order. Three papers were read and discussed at this session, on protective devices. The first was presented by J. A. Johnson, on "Reactors in Hydro-Electric Stations." This paper indicated that the advantages and limitations in the use of current-limiting reactors in hydro-electric stations are not so well recognized or understood as they are in steam-turbine stations, but it is coming to be realized that their use may be quite as justifiable in the former as in the latter. However, the installation of the reactors usually results in a decrease in the stability of synchronism. This limitation in the use of reactors is not very well understood. It was also pointed out that the asynchronizing effect of a sudden load change is approximately twice that of a gradual change of the same magnitude. The author described a case where there were 16 generators connected in groups of four to an

open-ring bus system, with 12 per cent. reactance between groups; a surge was started by the sudden removing of 20,000-kw. load on the end bus section and continued until the circuit-breakers opened and separated the sections. The conclusion was that since this amount of reactance required to create such a condition of instability is of the same magnitude as that required for protecting and localizing purposes, it follows that no installation of current-limiting reactance can be safely undertaken in a hydro-electric station without a thorough investigation of the effect of such an installation upon the synchronous stability of the station.

The second paper was presented by P. B. Juhnke, on the "Effect of Current-Limiting Reactors on Turbo-Generator Systems Under Conditions of Short-Circuit." This paper gave an account of a cable breakdown near one of the generating stations of the Commonwealth Edison Co. The breakdown resulted in a second breakdown on the same line within the station, which prevented the oil switches from automatically disconnecting the faulty circuit. The system is amply protected by reactors for generators and between bus sections. Comparisons were made of the maximum stresses encountered in the short-circuit as it occurred, and what they might have been without reactors, and the conclusion drawn was that without them the damage resulting would have been considerable and the interruption far more general and serious.

The third paper was by M. H. Collbohn, but owing to the author's absence it was presented by A. B. Taylor. The paper pointed out the dangers to which the neutral point of transformers connected to long-distance transmission lines are exposed through the building up of excessive potentials at this point under conditions of atmospheric lightning. The paper in full will be published in an early issue.

THE ELECTRO-PHYSICS SESSION

The electro-physics session was held Thursday morning, F. W. Peek, Jr., presiding. Three papers were presented. The first, "Corona and Rectification in Hydrogen," by J. W. Davis and C. F. Breese, was presented by C. Le G. Fortescue. This paper gives the results of an investigation of the corona discharge between coaxial cylinders in an atmosphere of hydrogen. Both direct- and alternating-current electromotive forces were used.

The second paper, "The Electric Strength of Air," by J. B. Whitehead and W. S. Brown, was presented by Mr. Whitehead, and outlined the results of the authors' work in making a careful examination of corona-forming voltages for alternating and for positive and negative continuous electromotive forces in the same apparatus and under the same conditions.

The third paper, "Oscillating-Current Circuits by the Methods of Generalized Angular Velocities," was presented by V. Bush. The purpose was to show that in the same way as alternating-current theorems are obtained by generalizing direct-current theorems, it is possible to obtain oscillating-current theorems by still further generalization. Mr. Bush showed on the blackboard how these theorems may be derived and gave examples of their application.

At the Thursday evening session President H. W. Buck occupied the chair and introduced Maj. J. H. Finney, of the Engineers' Reserve Corp, U. S. Army, who in a short address briefly outlined the various branches of service in this department. Captain J. H. Cuntz, of the Signal Reserve Corp, told about the work of this branch of the army.

Prof. R. A. Milliken was then introduced and gave an address on "Modern Physics." The speaker in a most remarkable address, explained some of the great achievements of modern physics and their importance in engineering. He told of what appeared to him as being the ten most important discoveries in the last twenty years in physical research. Many of these results and how they were accomplished were illustrated with lantern slides. In conclusion Professor Milliken called attention to the necessity of continuing the vast amount of research work that has been done in the past, in order to open up other mines of knowledge, if our highly developed civilization is to continue.

The Friday morning session was devoted to the consideration of direct-current motor controllers. The meeting was called to order by Vice-President J. F. Stevens. Two papers were presented: "Industrial Controllers With Particular Reference to the Control of Direct-Current Motors," by H. D. James; "Analysis of the Starting Characteristics of Motors," by K. L. Hansen. Both were read by Mr. James. In the first the author presents a series of tests on 15- and 20-hp., 230-volt, both constant and adjustable-speed direct-current shunt motors. These tests were made to determine the effect upon (1) the load driven by the motor, (2) the power supply, and (3) the motor operation. From the test the author draws the conclusion, in part, that it is practical with automatic acceleration to use one switch to short-circuit the armature resisance used with motors as large as 15 hp.; that the shunt field of small adjustable-speed motors can be reduced in one step under normal load conditions This practice can be safely followed with motors up to 50 hp., and adjustable-speed motors can use one-step resistance for dynamic breaking. Although in the discussion it was brought out that several installations had been operating for a number of years under conditions similar to those outlined in the paper, there was considerable opinion expressed that questioned such a practice.

The second paper is a mathematical derivation of expressions for the current, speed, torque and power at any time during the accelerating period when a shunt, series or compound motor is connected to the supply line.

The alternating-current motor-control session was held in the afternoon, with E. H. Martindale, chairman of the Industrial and Domestic Power Committee, presiding. R. E. Hellmund presented a paper on "Transient Conditions in Asynchronous Induction Machines and Their Relation to Control." A paper was presented by A. A. Gazda, on "Performance of Polyphase Induction Motors Under Unbalanced Secondary Conditions." The first paper considers a number of transient conditions in induction motors immediately after certain changes in the circuit connections are made. It was pointed out that where induction motors are started on low voltage and then the primary opened to throw over on normal voltage, conditions can be obtained where the effects following the change over may be worse than when starting directly from line pressure. Also overvoltage may be obtained with open-circuit secondaries, closed-circuit secondaries and over synchronous speeds.

Mr. Gazda's paper shows that the continuous operation of a wound-rotor induction motor, when the external resistance in the secondary phases are not equal, is feasible. The effects of single-phase secondaries upon the performance of polyphase motors is discussed.

The convention closed Friday evening with a dinner-dance held at the Hotel Astor for the members and their guests; 331 were in attendance.

ENGINEERING AFFAIRS

Phœnix Association, No. 24, N. A. S. E., will hold a dinner and dance on Thursday evening, Mar. 15, at the Hotel Netherland, Fifth Ave. and 59th St., New York City, and the committee assures all who attend a very enjoyable time.

The Providence Engineering Society will hold a meeting on Mar. 6, at which Frederick Ewing, engineer for the Huasteca Petroleum Co. and the Mexican Petroleum Co., will give a talk on "Fuel Oil." He will discuss the advantages of oil burning for large and small plants as compared with coal burning.

The American Institute of Consulting Engineers, Inc., at its annual meeting on Jan. 15, elected the following members of the Council to fill the places of retiring members: A. M. Hunt, L. B. Stillwell, W. J. Wilgus, G. S. Williams. At the Council meeting on Feb. 6 the following officers were elected for the year 1917: For president, George Gibbs; vice-president, L. B. Stillwell; secretary-treasurer, F. A. Molitor.

Atlantic City Council No. 4, American Order of Steam Engineers, held its twentieth annual banquet at the Hotel Jackson, Atlantic City, N. J., on Saturday evening, Feb. 17. Supreme Chief J. William Pairent was the toastmaster. An appetizing dinner was enjoyed by the two hundred seated in the main dining hall. The speakers included Mayor Harry Bacharach, Congressman Isaac Bacharach, William Le Compte of Jenkins Bros., and Col. William Bryant, commissioner of labor. A pleasing entertainment was furnished by Alice White, Genevieve Miller, Ida Dazell, Billy Murray and Jack Armour. The Committee of Arrangements comprised W. S. Price, J. A. Best, A. H. Francks, E. M. Plummer and Thomas Small.

Bridgeport Association, No. 4, N. A. S. E., held its nineteenth annual banquet on Thursday evening, Feb. 15, at the Hotel Stratfield, Bridgeport, Conn. Over 200 engineers and their wives and friends occupied tables in the main ballroom. Many prominent New England engineers were among the diners. When the coffee was reached Frank D. Anderson, the toastmaster, introduced J. Alex. H. Roberts, city clerk, who gave an interesting address in lieu of Mayor Wilson, who was absent from the city. The superintendent of the Connecticut trolley system then spoke and was followed by Warren Goodrich, chief engineer of the power house of the same company. Addresses were also made by Messrs. Porter, Quinlan, Bulkley and Grace. An entertainment was given by May Sullivan, Robert Stafford, Fred L. Bowden and Jack Armour. Dancing concluded the festivities.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular		Individual	
	Feb. 24, 1917	One Year Ago	Feb. 24, 1917	One Year Ago
Buckwheat	$3.40@4.40	$3.05@3.20	$4.30@4.50	$3.25@3.50
Rice	2.90@3.90	2.50@2.65	3.85@4.10	2.70@2.95
Boiler	2.75@3.75	.....	3.60@3.85	.....
Barley	2.65@3.65	2.20@2.35	3.50@3.75	2.35@2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Feb. 24, 1917	One Year Ago	Feb. 24, 1917	One Year Ago
Clearfields	$5.15@6.00	$1.70@2.35	$8.75@9.50	$4.25@4.75
Cambries and Somersets	5.50@6.25	1.90@2.60	9.00@9.75	4.50@5.30

One lighter load of Clearfield sold recently at $10.50 alongside.

Pocahontas and New River, f.o.b. Hampton Roads is $7@7.25, as compared with $2.80@2.90 a year ago; on cars Boston price is $10.50@11.25 against $5.25@5.50 a year ago.

*All-rail rate to Boston is $2 60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports (South Amboy, Port Reading and St. George) as compared with a year ago are as follows:

ANTHRACITE

	Circular*		Individual*	
	Feb. 24, 1917	One Year Ago	Feb. 24, 1917	One Year Ago
Buckwheat	$2.75	$2.75	$7.00@7.25	$2.90@3.30
Rice	2.20	2.25	5.00@5.50	2.05@2.30
Barley	1.95	1.75	4.00@4.25	1.55@1.80

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	South Amboy		Port Reading	Mine Price	
	Feb. 24, 1917	One Year Ago	Feb. 24, 1917	Feb. 24, 1917	One Year Ago
Clearfield	$7.25@7.50	$3.25@3.50	$7.25@7.50	$5.00@5.25	$1.70@1.95
South Forks	7.50@7.75	3.50@3.75	7.50@7.75	5.75@6.25	1.95@2.20
Nanty Glo	7.50@7.75	3.35@3,60	7.50@7.75	5.75@6.25	1.80@2.05
Somerset	7.25@7.50	3.25@3.50	7.25@7.50	5.00@5.25	1.70@1.95
Quehamoning	7.50@7.75	3.35@3.60	7.50@7.75	5.75@6.25	1.80@2.05

*Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally same at the same periods of the year and are fixed according to a regular schedule.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Feb. 24, 1917	One Year Ago	Feb. 24, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3 40	$2.30
Rice	2.10	.90	3.00	1.80
Boiler	1.95	....	3.15	....
Barley	1.85	.55	2.05	1.30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Feb. 24, 1917	One Year Ago
Slack	$5.00@5.25	$1.15@1.20
Mine-run	5.25@5.50	1.25@1.30
¾-in.	5.25@5.50	1.35@1.40

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump	$3.50@3.75	$3.75@4.00	$5.00@5.25	$3.25@3.50	$3.00@3.25
Lump	3.75@4.00	3.75@4.00	5.00@5.25	3.50@3.75	3.50@3.75
Egg	3.75@4.00	3.50@3.75	5.00@5.25	3.25@3.50	3.25@3.50
Nut	.....	.....	.....	3.25@3.50	3.00@3.50
No. 1 nut	3.75@4.00	.....	.....	.....	.....
No. 2 nut	3.75@4.00	.....	.....	.....	.....
No. 3 nut	3.50@3.75	.....	.....	.....	.....
No. 1 washed	3.75@4.00	.....	.....	.....	.....
No. 2 washed	3.50@3.75	.....	.....	.....	.....
Mine-run	3.50@3.75	3.25@3.50	4.75@5.00	3.25@3.50	3.00@3.25
Screenings	3.25@3.50	3.25@3.50	.....	3.25@3.50	3.00@3.25

Hocking lump, $4@4.25; splint lump, $4.25@4.50.

St. Louis—Price per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Feb. 24, 1917	One Year Ago	Feb. 24, 1917	One Year Ago	Feb. 24, 1917	One Year Ago
6-in. lump	$3.25	$1.65	$2.85	$1.45	$2.60@2.75	$1.35
2-in. lump	3.25	1.40	2.75	1.30	2.50	1.10
Steam egg	3.25	1.40	2.75	1.25	2.50	1.00
Mine-run	3.25	1.15	2.75	1.15	2.35	.95
No. 1 nut	3.25	1.40	2.75	1.20	2.50	1.10
2-in. screen	3.00@3.25	.95	2.50	.80	2.20	.80
No. 5 washed	2.75@3.00	.90	2.25@2.50	.80	2.10	.80

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Washed Mine-Run	Washed Nut
Pratt	$3.50@4.00	.....	.....
Big Seam	2.50@3.00	$2.50@3.00	.....
Black Creek	3.50@4.00	3.50@4.00	.....
Carbon Hill	3.00@3.50	3.00@3.50	.....
Cahaba	.....	3.50@4.00	.....

The demand for steam coal is so strong that the consumer readily buys most anything he can get, hence no differential in the price of straight mine-run and washed mine-run.

PROPOSED CONSTRUCTION

Colo., Hugo—H. E. Bacon has applied for franchise to build and operate an electric-light plant.

Del., Newark—The City Council will improve the electric-light plant.

D. C., Washington—Bureau of Supplies and Accounts, Navy Dept., Washington, D. C., soon to receive bids for furnishing under Schedule 677 at Navy Yard, Washington, D. C., 44,000 ft. steel conduit.

Ga., Americus—The Americus Public Service Co. will extend its generating and distributing systems.

Ill., Chicago—The Chicago Mill and Lumber Co., 900 North Sangamon St., will construct a new boiler and engine house. Estimated cost, $30,000. L. Guenzel, 332 South Michigan Blvd., Arch.

Ind., Mongo—The Farmers and Merchants Light, Heat and Power Co. has applied for permission to issue $500,000 bonds to improve 5 dams and water-power plants on the St. Joseph's and Fawn Rivers in northern Indiana and southern Michigan. Estimated cost, $278,250.

Ia., Marengo—The Iowa Electric Co. has been granted a franchise to erect a transmission line in Washington, Johnson and Muscatine Counties. J. M. Drabelle, Cedar Rapids, Engr.

Kan., Independence—The Kansas Gas and Electric Co. will install a 10,000-kw. power plant. Estimated cost, $1,000,000. J. H. LaGrant, Wichita, Pur. Agt. W. F. Murrow, Local Mgr.

Ky., Whitesburg—The Consolidation Coal Co. will extend its transmission lines from the central power station in Jenkins to supply electricity in Whitesburg, Kona and other central points. W. Burdine, Whitesburg, interested.

Maine, Yarmouth—The Town Comrs. have applied to the State Legislature for permission to install and operate an electric-light plant.

Mass., Boston—Bureau of Supplies and Accounts, Navy Dept., Washington, D. C., will soon receive bids for furnishing under Schedule 717 at Navy Yard, Boston, 1 set engine order telegraph system.

Mass., Boston—Bureau of Supplies and Accounts, Navy Dept., Washington, D. C., will soon receive bids for furnishing under Schedule 742 at Navy Yard, Boston, 120,000 ft. antennæ, insulated wire.

Mass., Chelsea—City has had plans prepared for a lighting and heating system in the city hall, central fire station and public library. A. L. Maggi, City Engr.

Mich., Grand Rapids—The Consumers Co. will build an addition to its steam power plant on Wealthy St., S. W. Estimated cost, $68,000.

Minn., Northrop—The Village Council will install an electric-light system. The energy will be obtained from Rapidan.

Mo., Portersville—City plans to rebuild its electric-light plant. J. B. Dreup, Pres.

Mont., Oswego—City plans to issue $10,000 bonds to install an electric-light plant.

N. J., Jersey City—The Union Cold Storage Co. will construct an addition to its power plant on 12th St. T. Adams, Pres.

N. J., Newark—Common Council has had plans prepared to install an electric-light plant at East Side Public Bath. Estimated cost, $12,000. M. R. Sherrard, City Mgr.

N. M., Columbus—The Columbus Electric Light and Power Co. has been organized with $200,000 capital stock; will install an electric power plant. J. L. Greenwood, interested.

N. Y., New York—Bureau of Supplies and Accounts, Navy Yard, Washington, D. C., will soon receive bids for furnishing under Schedule 742 at the Navy Yard, Brooklyn, 40,000 ft. interior communication cable, 4300 ft. steel galvanized conduit, 140 ft. telephone jacks, 21,000 ft. single conductor wire and 20,000 ft. twin conductor wire.

N. Y., Rochester—The Rochester Railway and Light Co. has had plans prepared for 3 additions to its power plant at Lower Falls. Estimated cost, $140,000. J. T. Hutchings, 34 Clinton Ave., Gen. Mgr.

Ohio, Foxtoria—The Seneca Wire and Manufacturing Co. will construct a power plant.

Ohio, Jamestown—The Dayton Power and Light Co. has taken over the plant and holdings of the Jamestown Electric Light Co. and will install transmission lines from Dayton to Jamestown to supply energy from the Dayton power plant. C. M. Peffly, Home Telephone Bldg., Dayton, Pur. Agt.

Penn., Philadelphia—Bureau of Supplies and Accounts, Navy Yard, Washington, D. C., will soon receive bids for furnishing under Schedule 742 at Navy Yard, Philadelphia, 3000 ft. steel galvanized conduit and miscellaneous resistance nickel chromium wire.

S. C., Charleston—Bureau of Supplies and Accounts, Navy Yard, Washington, D. C., will soon receive bids for furnishing under Schedule 696 at Navy Yard, Charleston, S. C., 13 contact maker gongs, 2 electric heaters, 2 contact bells, etc., makers, 2 gong pulls, 4 ventilating portable sets, 1 each fire room telegraph transmitter and indicator, 2 mechanical engine telegraph, 1 indicator transmitter, 5 rudder angle transmitters, 1 shaft revolution transmitter and 1 electric whistle outfit.

S. D., Kimball—The South Dakota Hydroelectric Corp., recently incorporated with $15,000,000 capital stock, will develop the water powers of the Missouri River in South Dakota to operate the hydro-electric plants. G. W. Adams, Council Bluffs, Ia., promoter.

Tenn., Alamo—Marion Darden will construct an electric-light and power plant.

Tex., Amarillo—City Comn. plans to install an electric-light plant. M. H. Hardin, City Mgr.

Wis., Brooklyn—The Brooklyn Electric Co. has been granted a franchise to install a distributing system.